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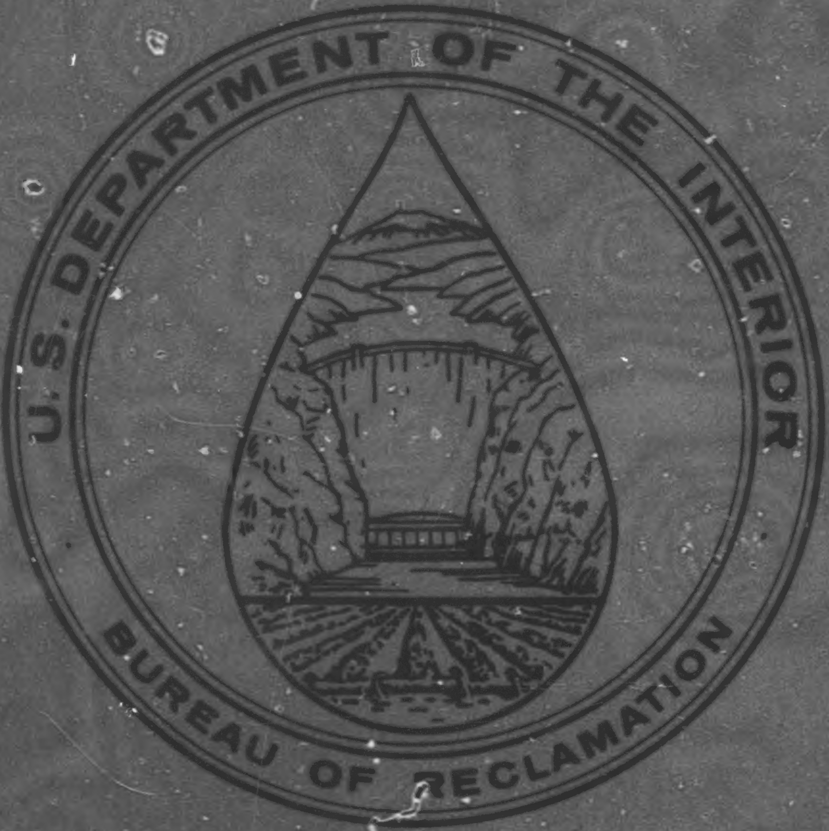
THE DROUGHT OF 1990

IN

THE WESTERN STATES
AND
OUTLOOK FOR 1991



UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

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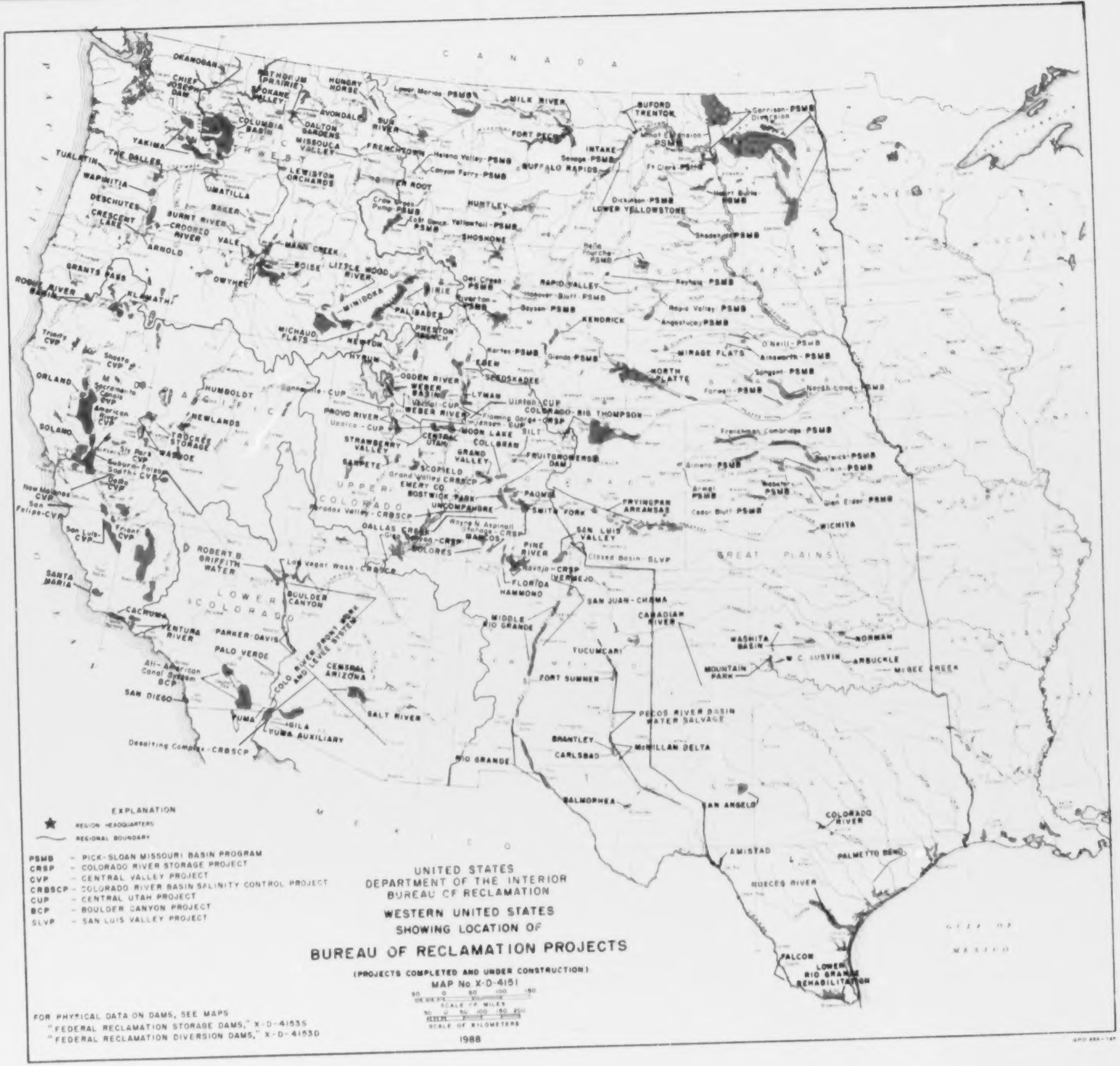
Mission: As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.


CANADA
PACIFIC NORTHWEST
MID-PACIFIC
UPPER COLORADO
LOWER COLORADO
GREAT PLAINS
MEXICO
GULF OF MEXICO
OKANOGAN
CHIEF JOSEPH DAM
RATHDRUM PRAIRIE
SPOKANE VALLEY
HUNGRY HORSE
COLUMBIA BASIN
AVONDALE
DALTON GARDENS
MISSOULA VALLEY
YAKIMA
TUALATIN
THE DALLES
WAPINITIA
UMATILLA
LEWISTON ORCHARDS
DESCHUTES
CRESCENT LAKE
BAKER
BURNT RIVER
CROOKED RIVER
VALE
ARNOLD
GRANTS PASS
ROGUE RIVER BASIN
KLAMATH
OWYHEE
MANN CREEK
BOISE
LITTLE WOOD RIVER
MINIDOKA
MICHAUD FLATS
PALISADES
RIRIE
PRESTON BENCH
NEWTON
HYRUM
Trinity CVP
Shasta CVP
ORLAND
Sacramento Canals CVP
American River CVP
SOLANO
Sly Park CVP
Auburn-Folsom South CVP
Delta CVP
New Melones CVP
San Felipe-CVP
San Luis-CVP
Friant CVP
HUMBOLDT
NEWLANDS
TRUCKEE STORAGE
WASHOE
SANTA MARIA
CACHUMA
VENTURA RIVER
ROBERT B. GRIFFITH WATER
Las Vegas Wash-CRBSCP
BOULDER CANYON
PARKER-DAVIS
PALO VERDE
All-American Canal System BCP
SAN DIEGO
YUMA
GILA
YUMA AUXILIARY
Desalting Complex-CRBSCP
COLO. RIVER FRONT WORK AND LEVEE SYSTEM
CENTRAL ARIZONA
SALT RIVER
Lower Marias PSMB
MILK RIVER
SUN RIVER
FORT PECK
FRENCHTOWN
Helena Valley-PSMB
Canyon Ferry-PSMB
BITTER ROOT
Crow Creek Pump PSMB
East Bench Yellowtail-PSMB
HUNTLEY
SHOSHONE
Owl Creek PSMB
Riverton PSMB
Boysen PSMB
Kortes PSMB
Glendo PSMB
EDEN
SEEDSKADEE
OGDEN RIVER
WEBER BASIN
LYMAN
Vernal-CUP
WEBER RIVER
Bonneville-CUP
PROVO RIVER
Upalco-CUP
Uintah CUP
Flaming Gorge-CRSP
Jensen-CUP
MOON LAKE
CENTRAL UTAH
STRAWBERRY VALLEY
SANPETE
SCOFIELD
COLLBRAN
SILT
GRAND VALLEY
Grand Valley CRBSCP
EMERY CO
BOSTWICK PARK
UNCOMPAHGRE
Paradox Valley-CRBSCP
DALLAS CREEK
Glen Canyon-CRSP
DOLORES
Wayne N. Aspinall Storage-CRSP
MANCOS
PAONIA
SMITH FORK
FRUITGROWERS DAM
COLORADO-BIG THOMPSON
FRYINGPAN ARKANSAS
SAN LUIS VALLEY
Closed Basin-SLVP
PINE RIVER
Navajo-CRSP
FLORIDA
HAMMOND
VERMEJO
SAN JUAN-CHAMA
MIDDLE RIO GRANDE
TUCUMCARI
FORT SUMNER
CANADIAN RIVER
PECOS RIVER BASIN WATER SALVAGE
BRANTLEY
CARLSBAD
McMILLAN DELTA
RIO GRANDE
BALMORHEA
SAN ANGELO
BUFORD TRENTON
INTAKE
Savage-PSMB
BUFFALO RAPIDS
Minot Extension PSMB
Garrison-PSMB
Garrison Diversion
Ft Clark PSMB
Dickinson PSMB
LOWER YELLOWSTONE
Heart Butte PSMB
Shadehill PSMB
Belle Fourche PSMB
RAPID VALLEY
Keyhole PSMB
Hanover-Bluff-PSMB
Rapid Valley PSMB
Angostura PSMB
KENDRICK
O'Neill-PSMB
MIRAGE FLATS
Ainsworth-PSMB
NORTH PLATTE
Sargent-PSMB
Farwell-PSMB
North Loup-PSMB
Frenchman Cambridge PSMB
Bostwick-PSMB
Kirwin-PSMB
Almena PSMB
Webster PSMB
Armel PSMB
Glen Elder PSMB
Cedar Bluff PSMB
WICHITA
WASHITA BASIN
NORMAN
W C AUSTIN
ARBUCKLE
McGEE CREEK
MOUNTAIN PARK
COLORADO RIVER
AMISTAD
PALMETTO BEND
NUECES RIVER
FALCON
LOWER RIO GRANDE REHABILITATION
GPO 854-747

EXPLANATION

★ REGION HEADQUARTERS
REGIONAL BOUNDARY

PSMB - PICK-SLOAN MISSOURI BASIN PROGRAM
CRSP - COLORADO RIVER STORAGE PROJECT
CVP - CENTRAL VALLEY PROJECT
CRBSCP - COLORADO RIVER BASIN SALINITY CONTROL PROJECT
CUP - CENTRAL UTAH PROJECT
BCP - BOULDER CANYON PROJECT
SLVP - SAN LUIS VALLEY PROJECT

FOR PHYSICAL DATA ON DAMS, SEE MAPS
"FEDERAL RECLAMATION STORAGE DAMS," X-D-41535
"FEDERAL RECLAMATION DIVERSION DAMS," X-D-41530

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

WESTERN UNITED STATES
SHOWING LOCATION OF

BUREAU OF RECLAMATION PROJECTS

(PROJECTS COMPLETED AND UNDER CONSTRUCTION)
MAP No X-D-4151

50 0 50 100 150
SCALE OF MILES
50 0 50 100 150 200
SCALE OF KILOMETERS

1988

THE DROUGHT OF 1990

IN

THE WESTERN STATES
AND
OUTLOOK FOR 1991

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

November 1990

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INTRODUCTION

The Bureau of Reclamation (Reclamation) is the West's primary water resources management agency. Reclamation operates more than 350 storage dams, delivering about 30 million acre-feet of water each year. It serves the needs of approximately 25 million people, provides irrigation water to an average 10 million acres of land each year, and generates an average 45 billion kilowatt-hours of hydroelectric energy, annually. In addition, Reclamation provides recreation, fish and wildlife, water quality, and other water-related benefits to the citizens of the West.

The amount of water available to meet these purposes varies from year to year. Water supply largely depends upon the pattern of winter snowfall; summer precipitation is negligible in most areas of the West. During winters with average or high snowfall (and with temperatures cold enough to accumulate a snowpack), spring runoff is sufficient to fill reservoirs for the season's demands. However, when winter weather is too dry or too warm to accumulate mountain snowpack, reservoirs may not fill.

In many Reclamation reservoirs, one winter of deficient snowpack may be insignificant. These reservoirs were designed to account for such variable weather conditions; thus, sufficient carryover storage from the previous year is available. Other reservoirs were sized to meet the demand for water even if three consecutive years of inadequate snowpack occur. However, some older Reclamation reservoirs were not designed to meet this requirement. And, for most reservoirs, carryover storage is no longer available when drought conditions extend beyond three years.

That condition—four years of consecutive drought—has now occurred in some areas of the West. Based on current water supply conditions, it is possible that we are entering the fifth year of water shortages in some of the West's most populous regions. The demand for water has steadily increased, placing greater stress on water supplies even under normal conditions.

Population growth and a national consensus about the importance of water for other values, such as instream uses, have increased demands. New burdens have been placed on some water supplies that were, until recently, adequate to fulfill all needs. The water supply requirements of southern California are a particular example, where potential water shortages are possible even in normal water years.

Water users in some areas of the West are jointly dependent on surface water and ground-water resources. In years of drought, users are more likely to depend on ground water. Such use places more demand on aquifers at a time when less recharge is occurring due to dry surface conditions. Although the relationship between ground water and surface water is important, this document only addresses surface water in relationship to Reclamation projects; it does not attempt to assess ground water concerns.

This report summarizes the drought conditions that occurred in many areas of the Reclamation West during water year 1990—from October 1, 1989, through September 30, 1990. Where information is available, some generalized predictions about the outlook for water supply in 1991 are provided. (For some Reclamation projects, reservoir operating plans for 1991 will not be prepared until after this report is published; therefore, the information herein may not represent the actual operating plans.) Next winter's precipitation patterns cannot be predicted with any degree of certainty; therefore, any predictions in this document should be treated as "educated guesses," based upon current conditions and the conditions expected if the winter season has high, average, or low precipitation.

The reader is cautioned that this report summarizes water supply conditions at some selected Reclamation projects; not all projects are represented. Projects were selected for inclusion in this document based upon the availability of data and the severity of potential impacts from drought. Further, the conditions of water supply do not necessarily correlate to the water demand from each project. Some projects are able to provide an adequate water supply for all needs even when reservoir storage appears to be particularly low. Therefore, water conditions must be examined in context of demand from each project, and comparisons between projects are not always appropriate. As a general rule of thumb, each project should be compared to its own historical record to determine the severity of water supply shortages. More detailed information about specific projects is available from Reclamation's regional offices:

Pacific Northwest Regional Office
John W. Keys, III, Regional Director
Box 043 - 550 West Fort Street
Boise, Idaho 83724-0043

Mid-Pacific Regional Office
Lawrence F. Hancock,
Regional Director
2800 Cottage Way
Sacramento, California 95825-1898

Lower Colorado Regional Office
Edward M. Hallenbeck,
Regional Director
P.O. Box 427
Boulder City, Nevada 89005

Upper Colorado Regional Office
Roland Robison, Regional Director
P.O. Box 11568
Salt Lake City, Utah 84147

Great Plains Regional Office
Roger K. Patterson, Regional Director
P.O. Box 36900
Billings, Montana 59107-36900

OVERVIEW
1990 WATER SUPPLY AND OUTLOOK FOR 1991

Water resources projects in the Bureau of Reclamation are separated into five regions: Pacific Northwest, Mid-Pacific, Lower Colorado, Upper Colorado, and Great Plains (see frontispiece map). The following discussion summarizes 1990 water supply conditions—including soil moisture, snowpack, accumulated reservoir inflow, and reservoir storage—by regions and, where appropriate, provides a preliminary projection of 1991's water supply under potential streamflow scenarios.

Pacific Northwest Region

The Pacific Northwest Region includes the States of Washington, Idaho, and Oregon and portions of Wyoming and Montana. The region encompasses the drainage basins of the Columbia River and coastal Oregon and Washington rivers.

Water Year 1990

Soil moisture conditions indicated normal to mild drought at the beginning of the 1990 water year for most of the region. Improvement was indicated for parts of the region in mid-winter, but, by the end of the water year, conditions had degraded to an extreme drought situation for about half of the region. Overall, soil moisture indicated much worse conditions for the region at the beginning of water year 1991 than at the beginning of the previous (1989) water year.

Snow accumulation in the region's river basins was below normal throughout the snowfall season. The areas most affected by low snowfall were the Oregon river basins where snow accumulation was less than 50 percent of normal for most areas. One exception was the South Fork Flathead River in northwestern Montana, where the snowpack was in the normal range on May 1, 1990.

Accumulated reservoir inflow ranged from well below normal to well above normal throughout the region by December 31, 1989, with the worst conditions in the Boise and Payette Rivers basins in western Idaho and the best conditions on the South Fork Flathead River in northwestern Montana. Generally, conditions neither improved nor deteriorated overall throughout the water year; however, some degradation in conditions occurred in the Boise and upper Snake Rivers basins in southwestern Idaho.

The region started the 1990 water year with a wide range of storage conditions—from well below normal in the Snake and Boise Rivers basins in Idaho, the Yakima River basin in Washington, and the Flathead River basin in Montana, to well above normal in the Malheur and Umatilla Rivers basins in

Oregon. Conditions fluctuated somewhat in some areas throughout the year; but, by year's end, overall conditions had generally degraded. By September 30, 1990, most basins in Oregon had storage conditions of less than 70 percent of normal and some less than 50 percent of normal. In southern Idaho, most storage was less than 50 percent of normal at the end of the year, with the exception of the Payette River where storage was above normal. Storage in Washington and northwestern Montana was near normal at year's end.

Notwithstanding localized water supply conditions in water year 1990, project water deliveries were near normal to normal. Notable exceptions were in the Boise River basin in Idaho and in the Malheur and Crooked Rivers basins in Oregon. Overall, irrigation demand in the Boise River basin averaged only 80 percent of normal, indicating that farmers were conserving water. End-of-year storage in the Boise River basin was only 58 percent of normal; but that level is very good, considering the poor streamflow and low reservoir storage at the beginning of the season. End-of-year storage in Prineville Reservoir in the Crooked River Project in Oregon was 62 percent of normal—the second lowest end-of-year storage in the project's 30-year history.

Projected Conditions for 1991

Reclamation will begin to forecast the 1991 season runoff early in January 1991, when the first snowpack observations are made. No water supply predictions are made during the fall unless a special need arises, and in such instances only reservoir refill probability estimates based on historical data are possible.

In general, end of season carryover storage is below normal and below last year's volume in many projects within the region. The Minidoka Project (Idaho-Wyoming) storage is 37 percent of normal, Boise Project (Idaho) storage is 57 percent of normal, and Owyhee Project (Idaho-Oregon) storage is 52 percent of normal. Vale Project (Oregon) storage was completely depleted in mid-August and now remains near empty, with less than 1 percent of normal storage. The Crooked River Project (Oregon) storage is 54 percent of normal, and storage in the Rogue River basin (Oregon) is 52 percent of normal. Above average runoff next year at the above projects would recover the storage reserves.

Yakima Project (Washington) storage is very near normal (96 percent), having had a normal 1990 season. Following a careful irrigation operation, the Payette River (Idaho) system storage is 120 percent of normal, despite well below average runoff in 1990.

MID-PACIFIC REGION

The Mid-Pacific Region includes most of California and portions of Nevada and Oregon. Projects include the Central Valley Project in California and other smaller projects on streams originating in the Sierra Nevada, lower Cascade, and southern California mountain ranges.

Water Year 1990

Water year 1990 began with indications of a possible end to the 3-year drought in California with the occurrence of strong storms in late September and October of 1989. The Central Valley Project had averted water shortages over most of the project in 1989 by virtue of an extraordinarily wet March. It appeared that there was a high probability for full water deliveries in 1990. Unfortunately, the outlook then began to worsen steadily.

The 6-month period November 1989 through April 1990 (the normal rainy season in California) produced only a few moderate rain storms interspersed with prolonged periods of dry weather. In February, Central Valley Project water contractors and water rights holders served by the project were informed of impending deficiencies in their water supplies during 1990. Most contractors were cut to 50 percent supplies and water rights entities were cut to 75 percent of full supply. By May 1, 1990, conservative forecasts showed Central Valley Project storage dropping to 2.9 million acre-feet in order to support even the deficient water deliveries earlier committed to by Reclamation.

Then came the "miracle May" of 1990. Two series of storms, the second (and larger) over Memorial Day weekend, produced by far the greatest reservoir inflows of the entire water year. These storms resulted in the wettest May of record at many locations in California, including Shasta and Trinity Dams.

Inflow from the May storms dramatically modified the water supply forecasts at a time of year when they are usually already accurately established. Reclamation restored all water rights entities to 100 percent supplies, as required by their agreements. The Central Valley Project also made an additional 83,000 acre-feet of water available to wildlife refuges. However, with only about 50 percent of desirable carryover storage, the project is again at risk of deficiencies in 1991.

The four water years 1987, 1988, 1989, and 1990 constitute one of California's most severe droughts of this century. Under California's Sacramento River Index, water year 1989 was classified a "below normal" year; the other three water years 1987, 1988, and 1990 were "critical" years .

Natural runoff during the 4-year period 1987-1990 is the lowest for this century in the California River basins above New Melones, Friant, and Folsom Dams. Central Valley Project-wide, only the droughts of 1928-34 and 1976-77 are even comparable in severity. Continuation of the present drought through 1991 could well constitute a "critical period" for the operation of the Central Valley Project more severe than those used to determine the yield and other capabilities of the project.

According to the indices of drought, measurements of soil moisture indicated very moist to mild drought to extreme drought conditions at the beginning of the 1990 water year. Conditions degraded as the water year progressed, and, by the end of the water year, conditions had degraded to an extreme drought situation for two-thirds of the region and moderate to severe drought for the remainder. Overall, soil moisture was much drier at the beginning of water year 1991 (September 30, 1990) than at the beginning of the previous water year (September 30, 1989.)

Snowpack in the tributary basins to the Central Valley in California was well below normal on February 1, 1990. By May 1, conditions had degraded to below 50 percent of normal in all basins. Consequently, accumulated inflow to the region's reservoirs was below normal to well below normal throughout the year. Some improvement and degradation were alternatively felt in various areas, but the year ended under similar circumstances to those at the beginning. Many areas had less than 50 percent of inflow for the year.

At the beginning of the 1990 water year, reservoir storage ranged from well below normal to near normal in the Central Valley of California and in the Klamath River basin in Oregon and California. Basins in southern California and in Nevada were, for the most part, well below normal at that time. Conditions degraded over the region through the water year and generally were well below normal throughout, except in the San Joaquin River basin where storage was near normal by year's end on September 30, 1990.

In Nevada, the Lahontan Project experienced water shortage conditions during 1990. In March, the Truckee-Carson Irrigation District set the Newlands Project water allocation at 65 percent of entitlement, but later revised the allocation to 70 percent due to rainfall during April. The Pershing County Water Conservation District initially set the Humboldt Project water allocations at 25 percent of entitlement but later adjusted the allocation to 27.5 percent, due to April precipitation. The water surface level of Lake Tahoe fell below its natural rim outlet to the Truckee River on September 14, resulting in conservation measures along the Truckee River. This is only the eleventh time since 1990 that the lake level has dropped so low.

Projected Conditions for 1991

Early analyses of water supply possibilities for 1991 indicate that full deliveries for Central Valley Project contractors will probably require normal or greater than normal runoff in 1991. The distribution of runoff throughout the project will have a bearing on water delivery capabilities because of the varying refill potential and localized operational requirements at each reservoir. In general, if 1991 normal runoff is evenly distributed over the project reservoirs, full water deliveries can be supported and some refill of carryover storage can be provided. For this reason, only normal or drier water supply scenarios currently are being analyzed in detail.

Preliminary operations forecasts have been performed for water year 1991 using three water supply scenarios: "median," "dry," and "critical." These projections demonstrate that there is a significant risk of continuing severe drought conditions and water supply deficiencies in 1991. Depending on the severity of conditions, which at this time can only be cast in terms of historical water supply probabilities, operation of the Central Valley Project in water year 1991 could stretch project capabilities to their limits. The September 30, 1990, storage in Central Valley Project reservoirs was 3.98 million acre-feet. The projected September 30, 1991 storage for each of the three water supply scenarios is 5.6 (median), 4.0 (dry), and 3.2 (critical) million acre-feet.

The Newlands Project and certain other areas in the Lahontan basin should not have shortages in 1991, if the runoff of the Truckee and Carson Rivers is at least 100 percent of normal. The runoff of the Humboldt River will need to be at least 120 percent of normal in 1991 in order to avoid shortages on the Humboldt Project.

LOWER COLORADO REGION

The Lower Colorado Region includes most of Arizona and portions of California, Nevada, Utah, and New Mexico. The region encompasses the portion of the Colorado River drainage basin below Lees Ferry, Arizona (near Page, Arizona).

Water Year 1990

Soil moisture measurements indicated predominantly moderate to severely dry conditions at the beginning of the 1990 water year for most of the region. Conditions improved and degraded, variously, as the water year progressed. Due to late season precipitation, conditions improved substantially in most of Arizona and southern Nevada by year's end, resulting in moist to very moist conditions. However, indices for northwestern Arizona and southern California still showed extreme drought conditions. Overall, soil moisture content was much improved in the region at the beginning of water year 1991 compared to conditions at the beginning of the previous water year.

Snowpack conditions in the river basins originating in Arizona and western New Mexico were well below normal throughout the snowpack accumulation season. Snowpack was less than 50 percent of normal in all of the basins by May 1, 1990.

Reservoir inflow to the region, as gaged by inflow to Lake Powell in the Upper Colorado Region, was less than 70 percent of normal early in the year and degraded to less than 50 percent of normal by the end of the water year.

Reservoir storage in the Lower Colorado Region, consisting of storage on the main stem Colorado River, remained at about 80 percent of capacity throughout the year. (Storage at year's end was about 3 percent of capacity less than it was at the beginning of the year.) Reservoir storage in this region is reported as a percent of capacity, rather than as a percent of average, because carryover storage is provided for many years. The average for a particular time of the year is not as meaningful as it is for a reservoir that provides carryover storage on an annual cycle.

The low runoff in 1990 continued the dry pattern that has been causing a drawdown in the Colorado River reservoirs. The below average flows of 1988, 1989, and 1990 have reduced the storage in Lake Mead by about 7 million acre-feet. Minimum deliveries of storage water must be maintained to meet obligations pursuant to the laws that govern administration of the Colorado River. Deliveries during 1990 required to meet these obligations were 9.1 million acre-feet.

Projected Conditions for 1991

Under the most probable water supply conditions for 1991, Lake Mead will not reach a storage level greater than that of 1990, due partly to the need to refill upper basin reservoirs and also due to the dry soil conditions in the upper basin. Lake Mead is projected to continue to drop through the fall and winter, reaching its seasonal low point in March 1991. Deliveries from Lake Mead in 1991 are projected to be 8.8 million acre-feet.

UPPER COLORADO REGION

The Upper Colorado Region includes most of Utah and New Mexico and portions of Nevada, Idaho, Wyoming, Colorado, and Texas. The region encompasses the Colorado River drainage above Lees Ferry, Arizona, the Rio Grande basin, and the closed-basin drainages flowing westward from the Wasatch Range in Utah.

Water Year 1990

Soil moisture content indicated mild to severe drought conditions at the beginning of the water year for most of the region, although extreme drought circumstances were indicated for parts of the region. As the water year progressed, the Colorado River and upper Rio Grande drainages degraded until most areas were in extreme drought conditions by the end of the water year. Due to late precipitation, the lower Rio Grande was moist to very moist by the end of the year. Overall, soil moisture measurements indicate much worse conditions for the region at the beginning of water year 1991 than at the beginning of water year 1990, except for the lower Rio Grande.

Snowpack in the river basins originating in western Colorado and southwestern Wyoming was below normal to well below normal on February 1, 1990, with the worst conditions located in southwestern Colorado. By May 1, conditions in southwestern Colorado had improved and those in southern Wyoming had degraded, but, overall, conditions remained below normal to well below normal.

Accumulated inflow to the region's reservoirs in the Colorado River basin was below normal to well below normal throughout the year. Total inflow to Lake Powell was less than 50 percent of normal. Also, accumulated inflow to Elephant Butte Reservoir on the Rio Grande was less than 50 percent of normal for the water year.

Reservoir storage was between 70 and 90 percent of capacity for reservoirs in the Colorado River and Rio Grande basins at the beginning of the water year. Storage conditions generally degraded for the region as the year progressed, with Lake Powell (the principal storage feature in the Colorado basin) dropping from 79 percent of capacity to 65 percent of capacity by year's end and Elephant Butte Reservoir on the Rio Grande dropping the same percentages through the year. As with the Lower Colorado Region, storage in this region is reported as a percent of capacity, rather than as a percent of average because carryover storage is provided by Lake Powell for many years at a time. The average for a particular time of the year is not as meaningful as it is for a reservoir that provides carryover storage on an annual cycle.

The runoff into Lake Powell during water year 1988 was approximately 70 percent of normal; in water year 1989, runoff was approximately 53 percent of normal; and in water year 1990, runoff was approximately 46 percent of normal. The low runoff years of 1988, 1989, and 1990 have caused a drawdown in each of the Colorado River system reservoirs. The vacant space on October 1, 1990, in the mainstem reservoirs, was about 16.7 million acre-feet. The vacant space has resulted from the three successive years of low inflow while maintaining the minimum deliveries of water out of storage facilities to meet obligations pursuant to "The Law of the River."

An abundance of mid-summer moisture in the Rio Grande Valley resulted in lower use of reservoir storage for the 1990 irrigation season than was predicted on March 1, 1990. Smaller projects generally used the predicted amount of reservoir storage, and they will need normal to above normal conditions to add water in storage in 1991. In general, conditions improved slightly over early forecasts as the season progressed.

Inflow to Elephant Butte Reservoir for 1990 for the March through July forecast period was 165,000 acre-feet, or 34 percent of normal. Inflow for water year 1990 was 351,000 acre-feet, or 40 percent of the long-term average. However, since combined storage at the end of 1989 was 1,706,000 acre-feet, or 201 percent of the long-term average, a full supply to all water users was available for the year.

The January 1, 1990, forecast for San Marcial Reservoir was 155,000 acre-feet, or 32 percent of normal. Each month thereafter, from February through May, the forecast was lower than 32 percent. The final forecast of June 1, 1990, ended at 34 percent. The forecast had very little impact on reservoir operations for 1990 because of the large amount of storage carried over from previous years.

Summer moisture also aided projects on the Pecos River; however, nearly all predicted use of reservoir storage was realized in 1990. Early predictions for streamflow runoff were very low (30-40 percent) throughout the basin. As the season progressed, late spring moisture increased the forecasts slightly, but heavy use of reservoir storage was anticipated. Beginning in early July, monsoonal type conditions in the basin developed and irrigation demand for reservoir storage decreased significantly. Good moisture conditions continued through September, resulting in good reservoir storage carryover potential for the 1991 season. Smaller Reclamation projects within the basin will require normal to above normal runoff to replenish reservoir storage used in the past 3 years.

Projected Conditions for 1991

In planning for 1991 Colorado River operations, three reservoir inflow scenarios were developed and analyzed. Statistically, inflows for these scenarios are approximately the upper quartile (equalled or exceeded 25 percent of the time), lower quartile (equalled or exceeded 75 percent of the time), and lower decile (equalled or exceeded 90 percent of the time). They have been respectively labeled the probable maximum, most probable, and probable minimum inflows.

The inflow volumes resulting from these assumptions were used as input data in Reclamation's monthly reservoir operation planning computer model, which is used to plan reservoir operations for the upcoming 12-month period. With the three levels of assumed water year 1991 inflow and reservoir storage conditions, studies showed that no project shortages would occur under any inflow scenario.

For the Rio Grand Project, projections for 1991 project operations were made for each of three water supply scenarios: the most probable (100 percent of normal), the reasonable minimum (25 percent of normal), and the reasonable maximum (200 percent of normal).

With the most probable runoff, a full supply of water would be available to most users along the lower Rio Grande. Further, this condition would result in a near full supply for the larger projects on the upper Rio Grande. Smaller projects in the upper Rio Grande would experience minor shortages.

With the reasonable minimum runoff, a full supply of water would be available to all users along the lower Rio Grande; however, there would be a serious shortage in 1992. With careful management of existing storage, larger projects like the Middle Rio Grande will get through the season. Extreme surface flow shortages would develop on the Pecos River, as carryover storage is essentially nonexistent at the present. This would result in farmers relying heavily on ground-water sources.

The reasonable maximum runoff would result in a full supply to all users on the lower Rio Grande. All projects within the upper Rio Grande basin would have full supplies, although the Middle Rio Grande Project would require supplemental releases in the late season. Conditions within the Pecos River basin under this scenario would provide a full water supply to Carlsbad Irrigation District, with some carryover storage potential.

GREAT PLAINS REGION

The Great Plains Region is Reclamation's largest region. It includes all of the States of North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma. In addition, it includes most of Montana, Wyoming, and Texas and about half of Colorado. It encompasses the Missouri River drainage and other tributaries to the Mississippi and Gulf Coast.

Water Year 1990

Soil moisture measurements varied widely at the beginning of the water year over this large region. On October 1, 1989, most of the region was in drought, ranging from mild to extreme drought circumstances. Exceptions were in northwestern Montana and southern Kansas and central Oklahoma, where moist conditions existed. As the year progressed into the spring and summer, additional moist areas were indicated, particularly in Kansas, Oklahoma, and northern Texas. However, by the end of the water year, very few areas with moist soil conditions remained. Overall, September 30, 1990, conditions in the region ranged from mild to extreme drought, with the extreme conditions concentrated mostly in the north. Some near-normal and moist conditions existed in Oklahoma and Texas at year's end. Overall, the soil moisture content indicated that conditions in the region at the beginning of water year 1991 on October 1, 1990, were similar to those at the beginning of the previous water year on October 1, 1989, but with some areal redistributions.

Snowpack on February 1, 1990, ranged from slightly below normal to near normal for the river basins originating in Montana, Wyoming, and Colorado. The range of conditions remained about the same near the end of the snow season on May 1, 1990, with some improvement in some basins in eastern Colorado.

Accumulated reservoir inflow ranged from above normal to below normal throughout the year. One of the more critical areas was the North Platte River basin originating in southeastern Wyoming. Two basins that were near normal were the Cheyenne River basin in Wyoming and South Dakota and the South Platte River basin in northeastern Colorado.

Reservoir storage was generally near normal in the tributaries to the upper Missouri River at the beginning of the 1990 water year and below normal on the tributaries to the lower Missouri River. By year's end on September 30, 1990, conditions were generally similar to the first of the year throughout the region, except in the Cheyenne and North Platte Rivers drainages in Wyoming, South Dakota, and Nebraska where conditions had degraded to well below normal.

Project water delivery shortages were experienced during water year 1990 in the Beaverhead River basin in Montana, the North Platte and Wind River basins in Wyoming, the James River basin in South Dakota, and several smaller Reclamation projects in Nebraska and Kansas. Because of the drought's impact on the Beaverhead River basin's (Clark Canyon Reservoir) water supply, the irrigation season was discontinued approximately 6 weeks earlier than normal.

Projected Conditions for 1991

Water deliveries for most projects in the Great Plains Region for 1991 should be adequate under most water supply scenarios, except for those projects that ended the year with low carryover storage. Expected conditions for two projects under dry conditions at the end of 1990 are discussed in the following paragraphs.

Bull Lake (Wind River Project) began the year with a content of 83,513 acre-feet (88 percent of normal). If 1991 inflows are near or above normal, Bull Lake would be expected to fill and have an adequate water supply for irrigation. However if lower decile inflows (equalled or exceeded 90 percent of the time) occur and a Wind River instream flow of 252 cubic feet per second is maintained, the reservoir will only fill to about 100,000 acre-feet, or about two-thirds full. If that occurs, the water supply would not be adequate to meet all irrigation needs, and the reservoir would be drafted to an unusually low level by the end of the year.

Based on September 30, 1990, storage, Clark Canyon Reservoir in the Beaverhead River basin would be expected to fill to the top of the joint-use pool only under high runoff conditions. Reservoir storage would be expected to fill to 155,000 acre-feet, or about 23,000 acre-feet below the top of the joint-use pool—during a normal runoff year. Storage under normal runoff conditions would be adequate to satisfy irrigation demands during the 1991 irrigation season. Under low runoff conditions, storage would be expected to fill to 130,000 acre-feet, or about 48,000 acre-feet below the top of the joint-use pool. Low runoff probably would result in shortage of irrigation water by the end of the 1991 irrigation season.

THE 1990 DROUGHT—AN ILLUSTRATED HISTORY

Portions of the West experienced a fourth year of drought in 1990. Low moisture conditions were evident based upon the indices, or measurement tools, used to assess drought. Although many indices demonstrate water supply conditions, each index measures a different factor.

Due to climate variables and water storage development in the Western United States, no single index can reflect all of the variables needed to measure drought. This chapter contains illustrations to demonstrate five different indices. Taken together, they show the growth or decline of drought in 1990, related to Bureau of Reclamation projects.

In the West, water storage in manmade reservoirs changes the natural water cycle. The amount of water that remains from one year to the next in those reservoirs may change the water supply picture. This carryover storage tends to mask the severity of drought until consecutive dry years lead to reservoir storage depletion. However, to assess the total water supply picture, the following indices are helpful: the Palmer Drought Severity Index, winter snowpack, streamflow forecasts, accumulated reservoir inflow, and reservoir storage supply. The remainder of this chapter illustrates these index measurements.

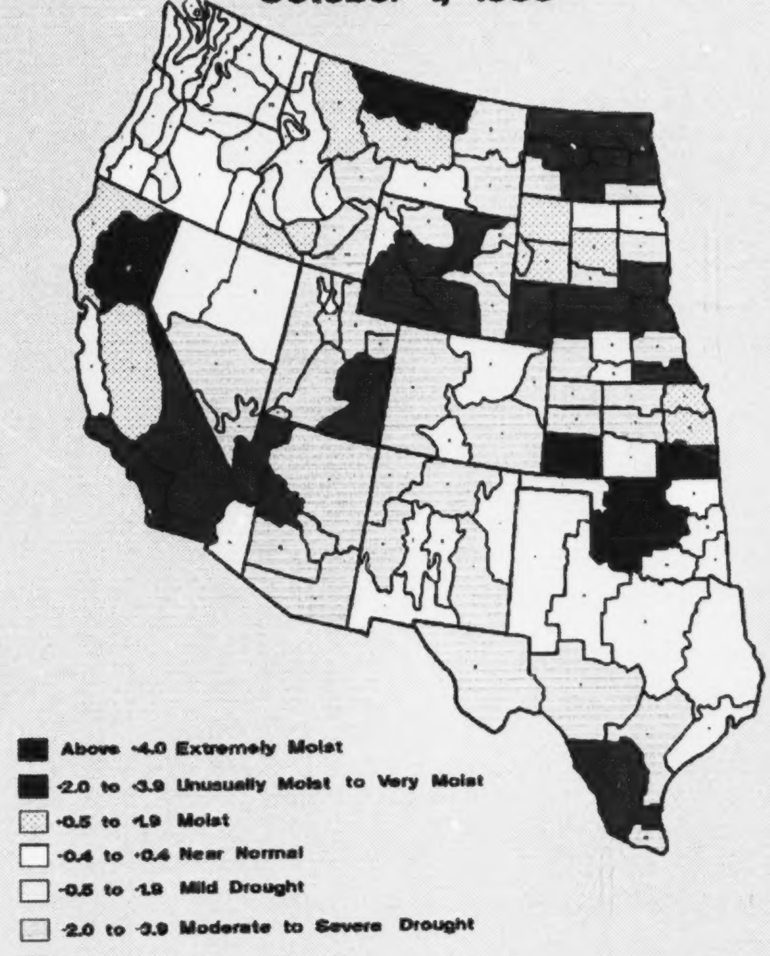
Palmer Drought Severity Index

The Palmer Drought Severity Index (PDSI) is a measurement tool for relative dryness or wetness, indicating prolonged and abnormal deficiencies or excesses of moisture. PDSI calculations are made from such indices as weekly precipitation totals, weekly average temperatures, moisture content of the soil, evapotranspiration rates, and previous indexes. The PDSI is based upon a scale of values, with values greater than +4 (wet) and less than [illegible] dry) representing extreme conditions.

The PDSI is an important climatological tool for evaluating the scope, severity, and frequency of prolonged periods of abnormally dry or wet weather. The index does not consider availability of snowmelt runoff, reservoir storage, or the availability of ground-water resources which can significantly influence an evaluation of water supply projections for a given area. The value of the PDSI is that it can provide important information about the following concerns: Will irrigated crops require more than the usual amount of water? Will precipitation run off into water channels or be absorbed into the soil? What is the degree of fire danger?

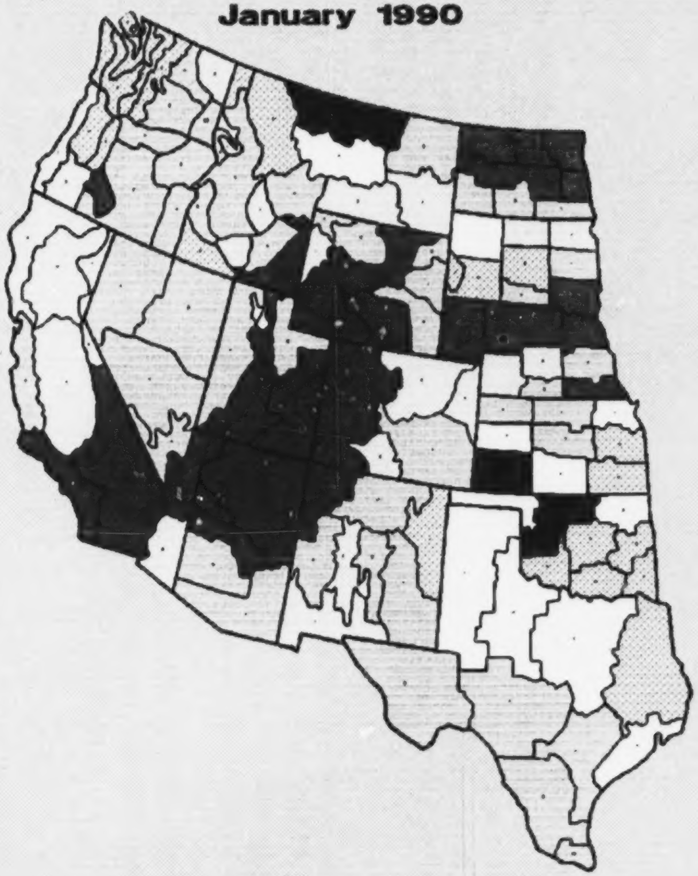
The PDSI maps on the following pages show soil moisture conditions at four intervals during 1990. As illustrated, soil moisture conditions in some sections of the West started dry and became even more arid as the season progressed. In particular, areas of California and the Colorado River Basin were extremely dry, causing increased water demand from storage for consumptive use.

PALMER DROUGHT SEVERITY INDEX RATINGS
October 1, 1989


■ Above +4.0 Extremely Moist
■ +2.0 to +3.9 Unusually Moist to Very Moist
▨ +0.5 to +1.9 Moist
☐ -0.4 to +0.4 Near Normal
☐ -0.5 to -1.9 Mild Drought
☐ -2.0 to -3.9 Moderate to Severe Drought
■ Below -4.0 Extreme Drought

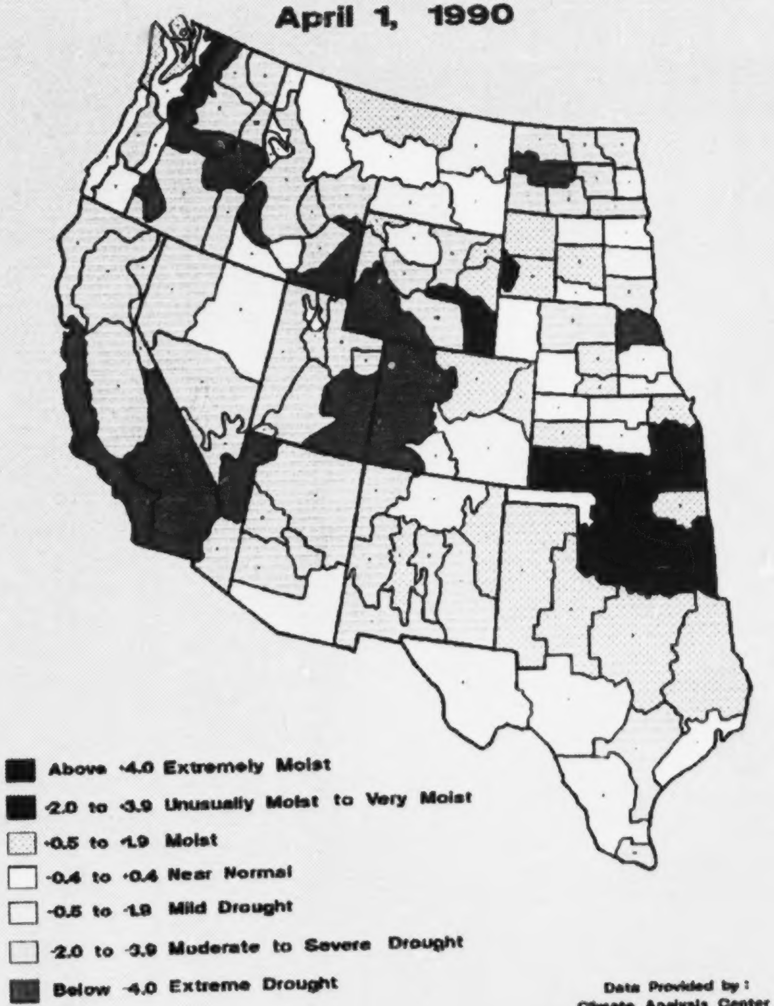
Data Provided by :
Climate Analysis Center
National Weather Service
Some Data are Preliminary

PALMER DROUGHT SEVERITY INDEX RATINGS
January 1990



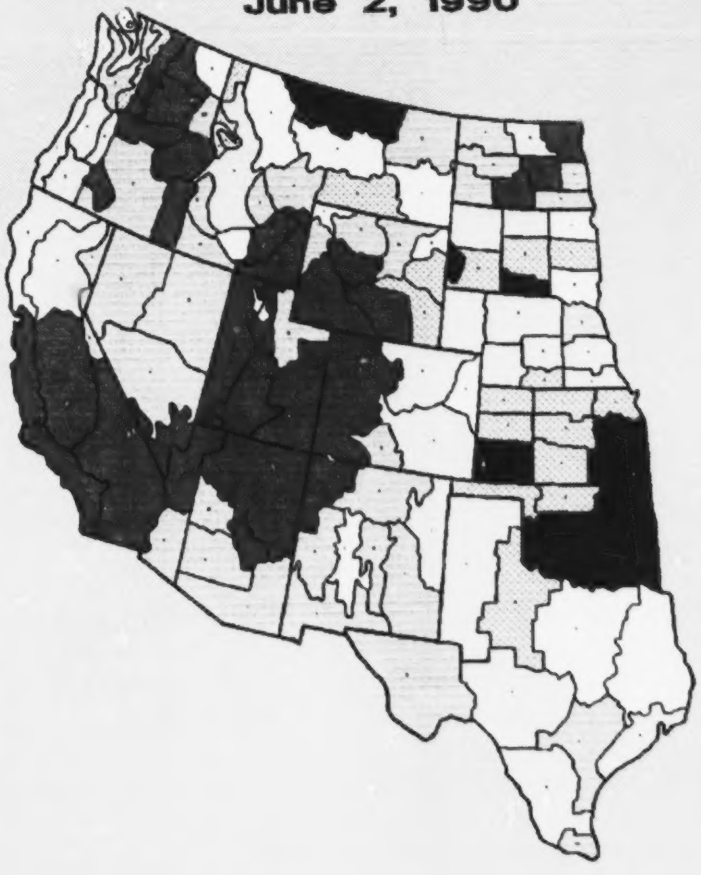
Data Provided by :
Climate Analysis Center
National Weather Service
Some Data are Preliminary

PALMER DROUGHT SEVERITY INDEX RATINGS
April 1, 1990


■ Above +4.0 Extremely Moist
■ +2.0 to +3.9 Unusually Moist to Very Moist
▨ +0.5 to +1.9 Moist
☐ -0.4 to +0.4 Near Normal
☐ -0.5 to -1.9 Mild Drought
☐ -2.0 to -3.9 Moderate to Severe Drought
■ Below -4.0 Extreme Drought

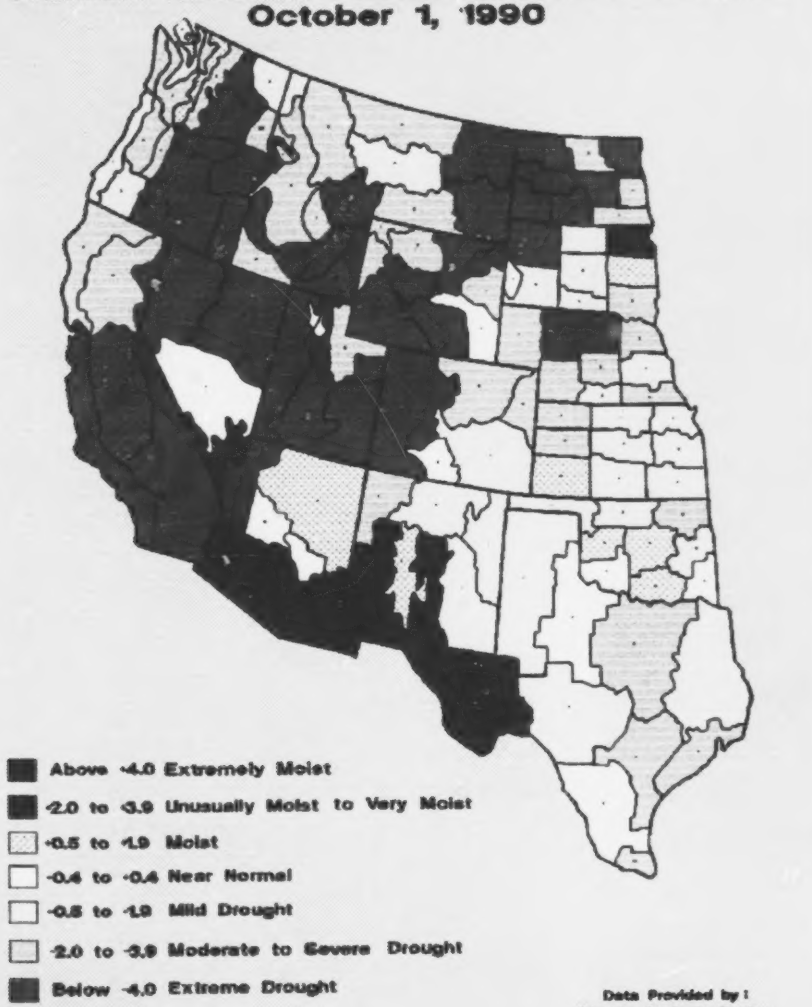
Data Provided by :
Climate Analysis Center
National Weather Service
Some Data are Preliminary

PALMER DROUGHT SEVERITY INDEX RATINGS
June 2, 1990



Data Provided by :
Climate Analysis Center
National Weather Service
Some Data are Preliminary

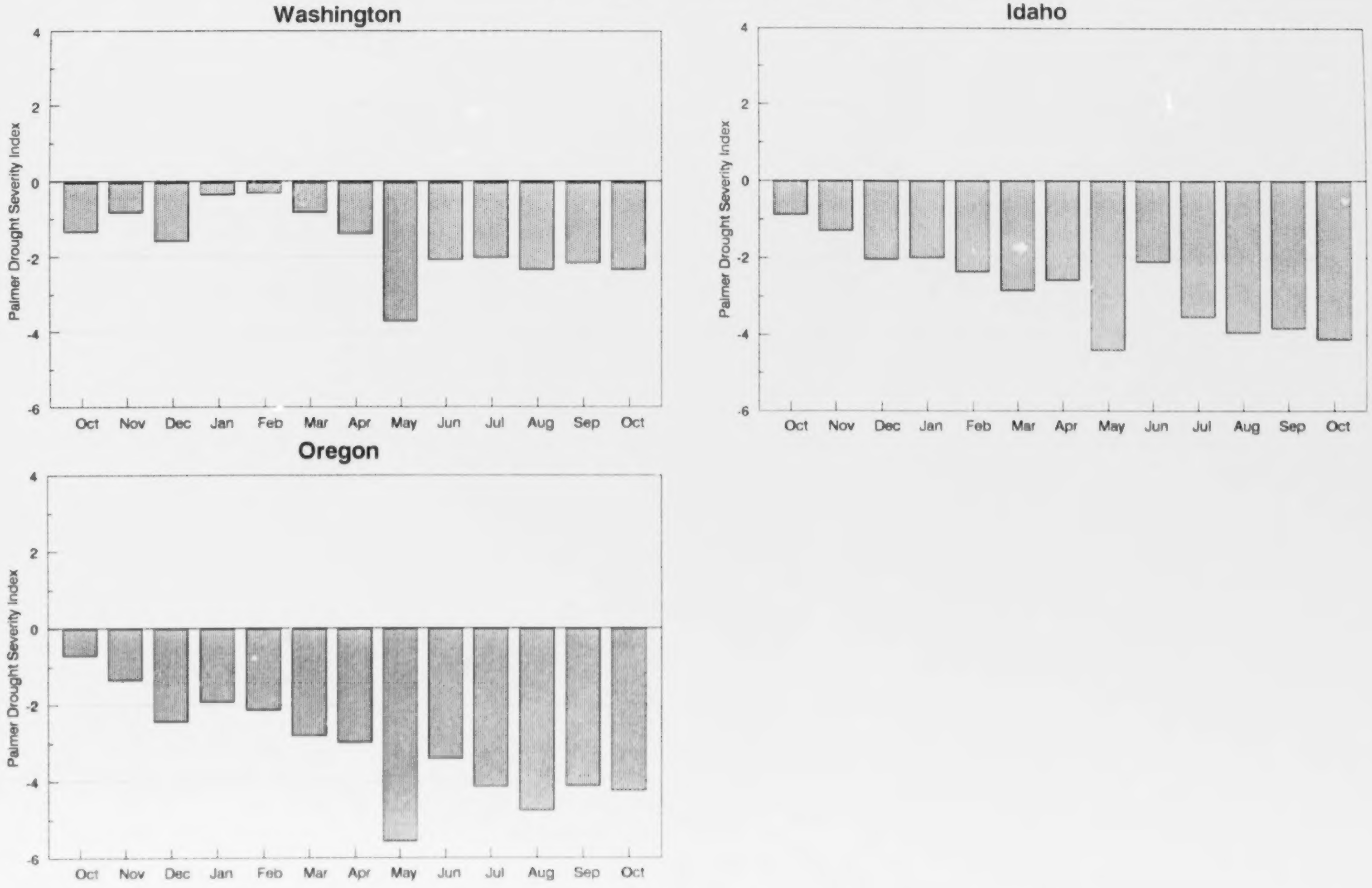
PALMER DROUGHT SEVERITY INDEX RATINGS
October 1, 1990


■ Above +4.0 Extremely Moist
■ +2.0 to +3.9 Unusually Moist to Very Moist
▨ +0.5 to +1.9 Moist
☐ -0.4 to +0.4 Near Normal
☐ -0.5 to -1.9 Mild Drought
☐ -2.0 to -3.9 Moderate to Severe Drought
■ Below -4.0 Extreme Drought

Data Provided by:
Climate Analysis Center
National Weather Service
Some Data are Preliminary

Palmer Drought Severity Index Trend, October 1989 - October 1990

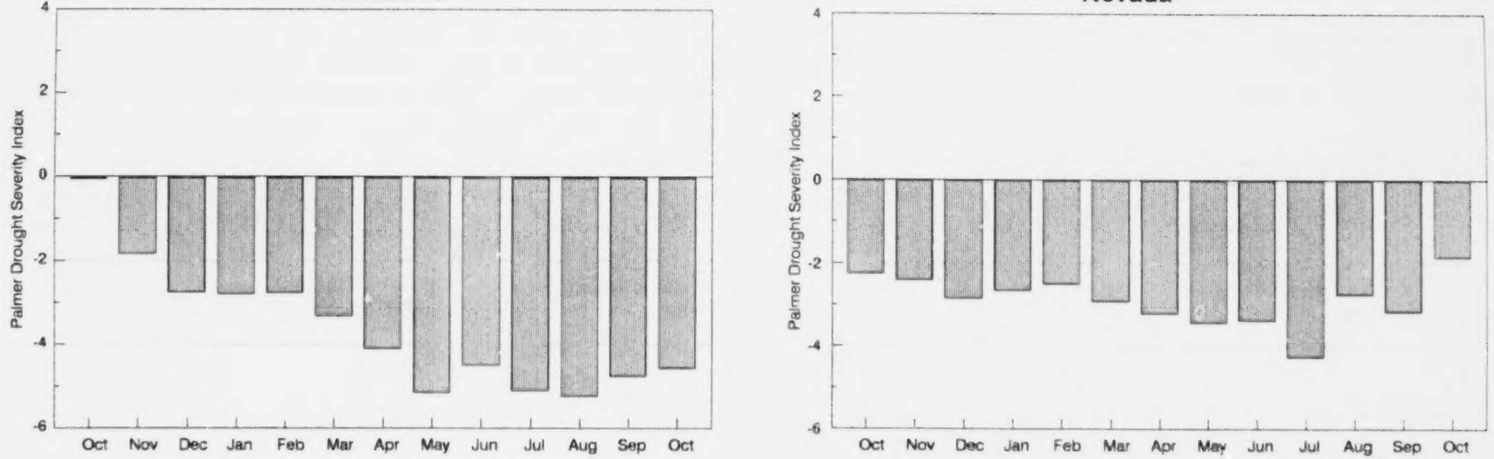
(Average of All Climate Division Indices)



Notes:
1. Data for October to March are monthly values
2. Data for April to October are first of month values
3. Data Provided by: National Weather Service, National Climatic Data Center
4. The reader is cautioned that these data are averages for all climate divisions within each state and that substantial variability may occur within a state.

Palmer Drought Severity Index Trend, October 1989 - October 1990

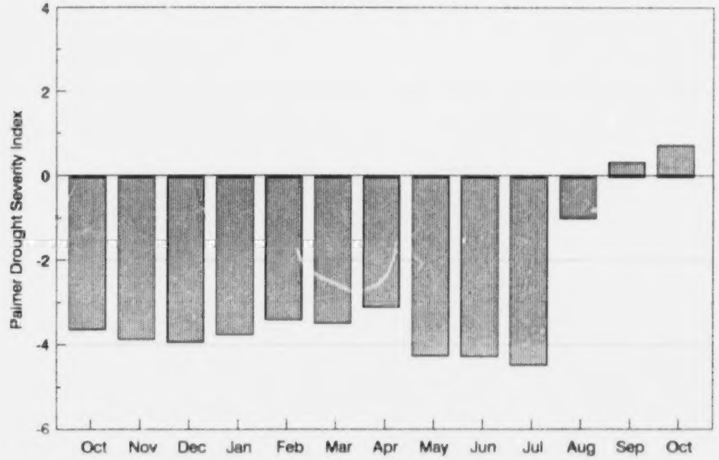
(Average of All Climate Division Indices)



California

Nevada

Arizona



Notes:
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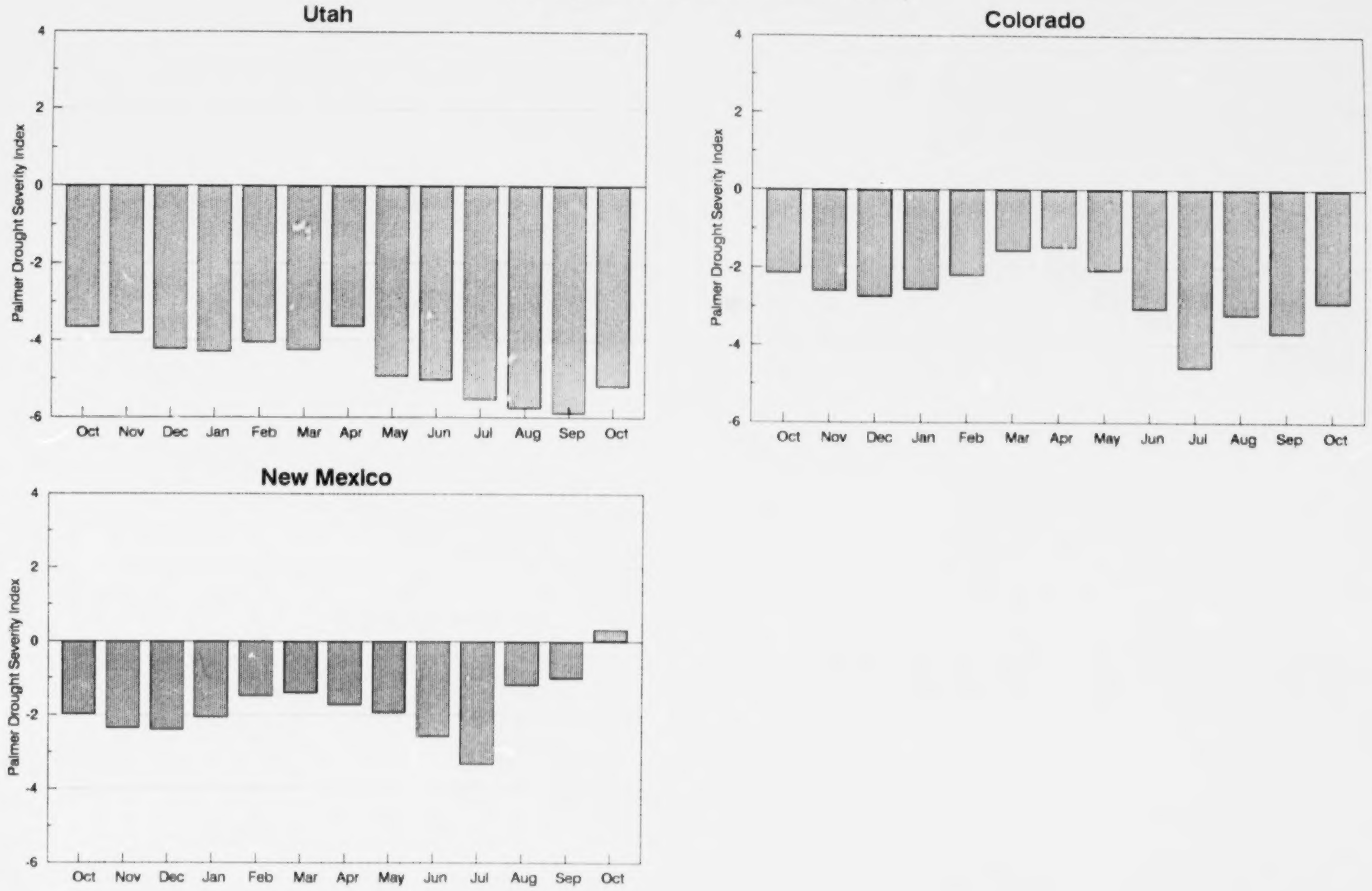
Palmer Drought Severity Index Trend, October 1989 - October 1990

(Average of All Climate Division Indices)

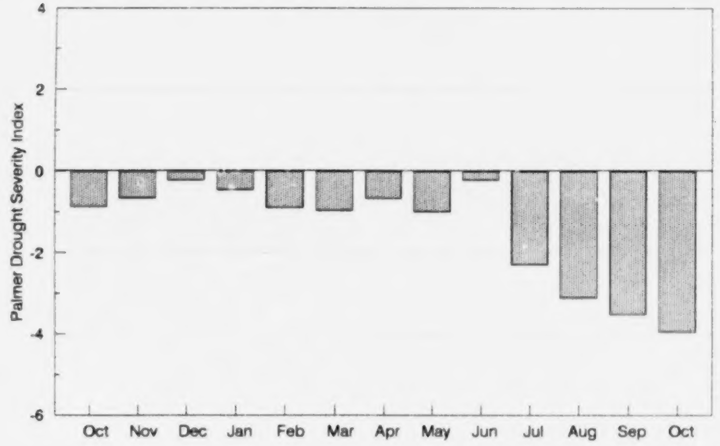


Notes:
1. Data for October to March are monthly values
2. Data for April to October are first of month values
3. Data Provided by: National Weather Service, National Climatic Data Center
4. The reader is cautioned that these data are averages for all climate divisions within each state and that substantial variability may occur within a state.

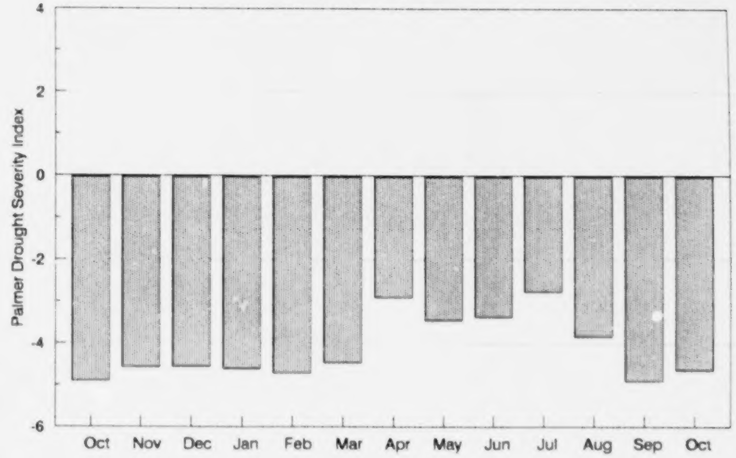
Palmer Drought Severity Index Trend, October 1989 - October 1990

(Average of All Climate Division Indices)

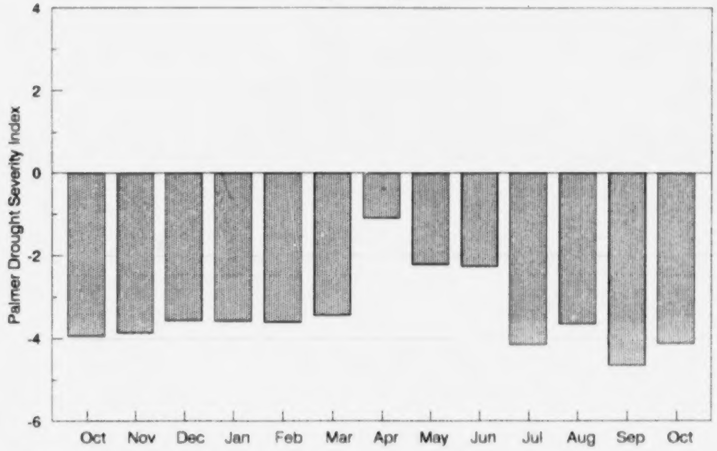
Montana



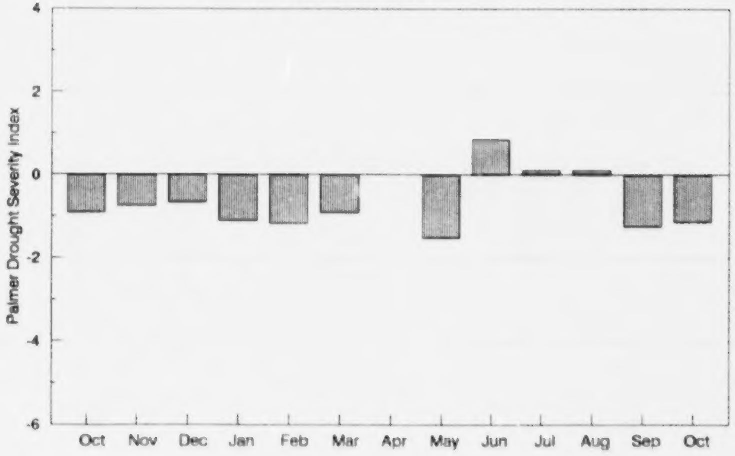
North Dakota



Wyoming



South Dakota

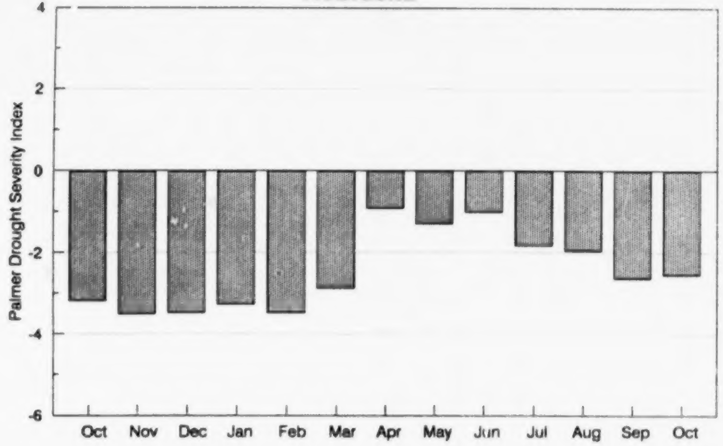


Notes:
1. Data for October to March are monthly values
2. Data for April to October are first of month values
3. Data Provided by: National Weather Service, National Climatic Data Center
4. The reader is cautioned that these data are averages for all climate divisions within each state and that substantial variability may occur within a state.

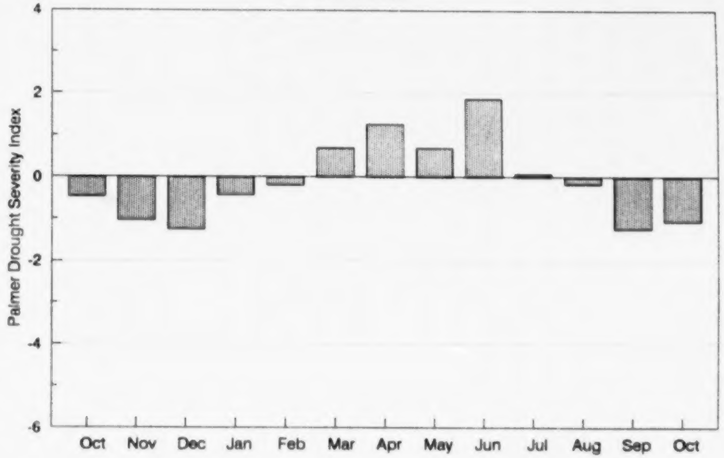
Palmer Drought Severity Index Trend, October 1989 - October 1990

(Average of All Climate Division Indices)

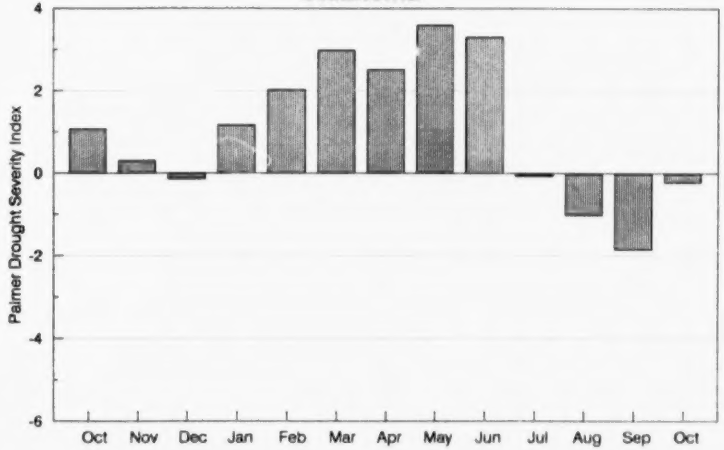
Nebraska



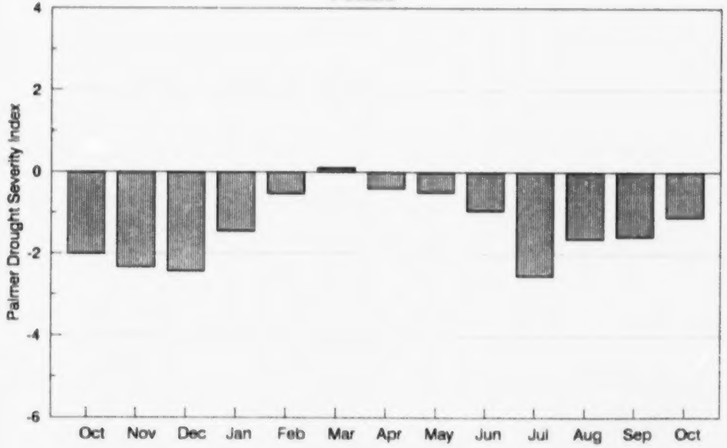
Kansas



Oklahoma



Texas



Notes:
1. Data for October to March are monthly values
2. Data for April to October are first of month values
3. Data Provided by: National Weather Service, National Climatic Data Center
4. The reader is cautioned that these data are averages for all climate divisions within each state and that substantial variability may occur within a state.

Snow Water Equivalents

Most Reclamation projects rely on winter precipitation for project water supplies and replenishment of reservoir storage. The winter snowpack that accumulates at higher elevations is critical. Snowpack indicates the amount of water that will be captured in the lower elevation reservoirs, and, thus, available for storage and release during the dry summer season. Low snowpack conditions indicate low reservoir inflow; very high snowpack conditions, particularly when associated with high carryover storage, indicate the potential for spring floods. Reservoir operations—the water release schedule—must consider both the amount and timing of the spring snowmelt runoff.

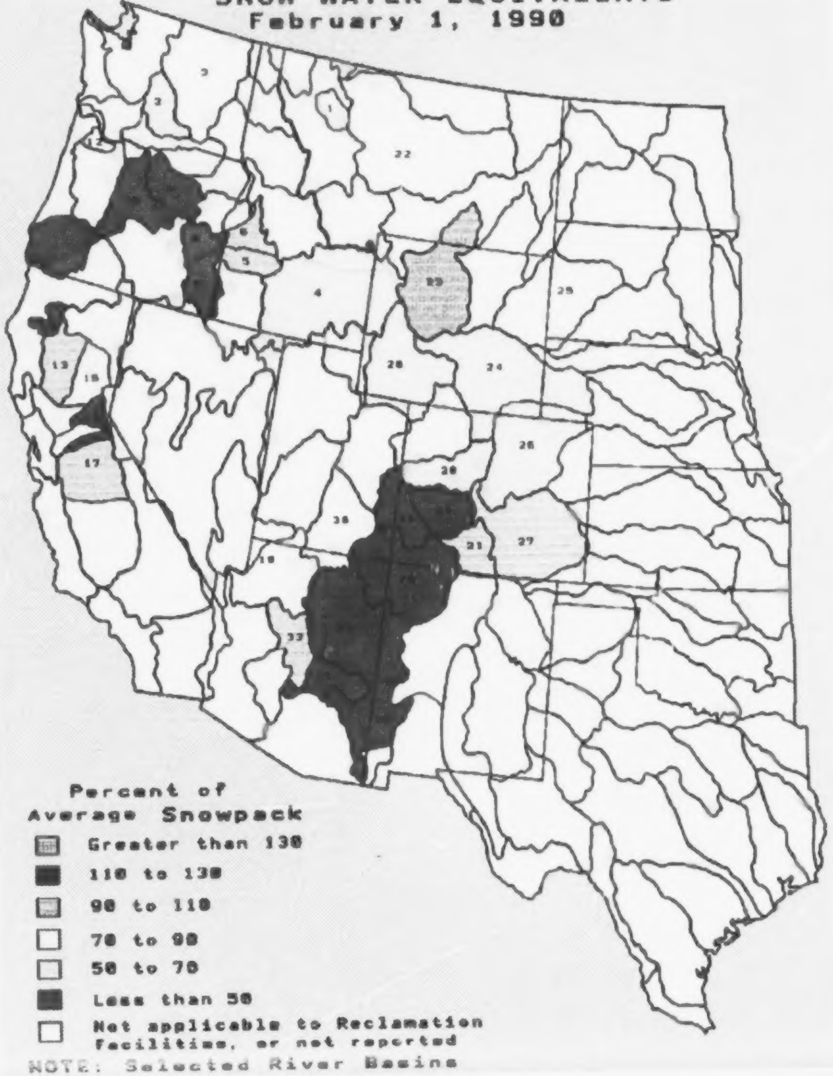
Snowpack can be thought of as "inches of water" temporarily stored in a frozen reserve. Two factors are considered: (1) the depth of the snow and (2) its moisture content. Deep snow may actually yield very little water if it is dry and powdery. Therefore, both factors are used to determine "snow water equivalents" which are an indication of the amount of reservoir inflow to be expected for the year.

Reservoir storage availability is largely based upon snowfall, and Reclamation begins its storage availability forecasts as early as possible each winter. Nevertheless, in many areas, a prediction of water supply for the following summer contains high levels of uncertainty until the winter storm season ends.

The following maps illustrate the snow water equivalents at two points during the winter of 1989-1990. Both maps summarize conditions as percentages of average. Numbers on the subbasins correspond to numbers on the following table, which provides a more detailed tabulation of the index measurement. Subbasins were chosen for illustration based upon availability of data and applicability to Reclamation projects.

In the West, most snow typically accumulates from January through April. Thus, the February 1, 1990, map shows the snowpack available near the beginning of the season, and the May 1, 1990, map shows the snow water equivalents near the end of the season. As shown, the percentages were extremely low in many areas. Particularly severe were areas of Oregon, California and Arizona. (Drought conditions in Arizona were relieved later in the season by a series of rain storms.)

SNOW WATER EQUIVALENTS
February 1, 1990


3
2
1
22
6
5
4
23
25
13
15
28
24
17
26
20
36
21
27
19
33
Percent of
Average Snowpack
▦ Greater than 130
■ 110 to 130
▨ 90 to 110
☐ 70 to 90
☐ 50 to 70
■ Less than 50
☐ Not applicable to Reclamation facilities, or not reported
NOTE: Selected River Basins

SNOW WATER EQUIVALENTS
May 1, 1990

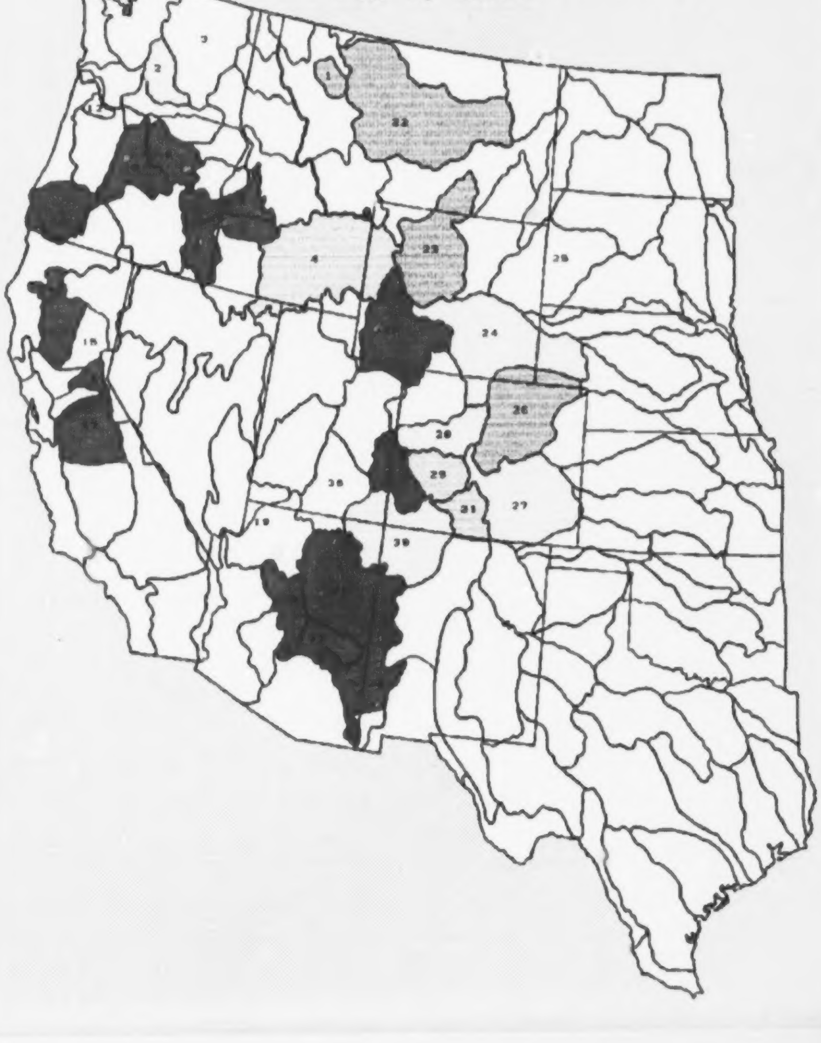

3
2
1
22
4
23
25
15
24
26
20
36
29
31
27
19
39

Table 1
SNOW WATER EQUIVALENTS[1]

River Basin Number	Basin	February 1, 1990	May 1, 1990
		percent of average	
1	South Fork Flathead	N/A	94
2	Yakima	83	76
4	Upper Snake	79	50
5	Boise[2]	55	40
6	Payette	55	40
7	Owyhee[3]	40	13
8	Malheur	40	13
9	Umatilla	17	9
10	Deschutes	17	40
11	Rogue[4]	13	13
13	Sacramento	54	28
14	Trinity	43	1
16	American	49	17
17	San Joaquin	61	23
18	Stanislaus	39	12
20	Colorado Headwaters	71	78
21	Upper Rio Grande	53	59
22	Upper Missouri	N/A[5]	96
23	Bighorn	100	109
24	North Platte	80	77
26	South Platte	80	100
27	Arkansas	62	79
28	Upper Green	87	49
29	Gunnison	44	68
30	San Juan[6]	23	76
31	Salt	17	0
32	Little Colorado	23	22
33	Verde	67	1
34	San Francisco-Gila	45	41
35	Dolores	23	76

---

[1] Equivalent depth of water contained in the snow. Basin numbers correspond to numbers on the map.

[2] Data for the Boise River basin are combined with Payette River basin data prior to averaging.

[3] Owyhee River basin data are combined with Malheur basin data prior to averaging.

[4] Rogue River basin data are combined with Umpqua River basin data prior to averaging.

[5] Not available.

[6] San Juan basin data is combined with Dolores River basin data prior to averaging.

Streamflow Forecasts

Streamflow forecast data are prepared by the Soil Conservation Service and the National Weather Service. Forecast data are compiled as of the first day of each month during the winter and spring months. Forecasts are important to reservoir operators because they provide another indicator of reservoir inflow to be used in determining how the spring runoff is likely to occur and how reservoirs should be operated.

The maps on the following pages show a summary of streamflow predictions that were available during the late winter and spring of 1990. It was apparent, based upon these forecasts, that much below average streamflow was likely over a large portion of the West.

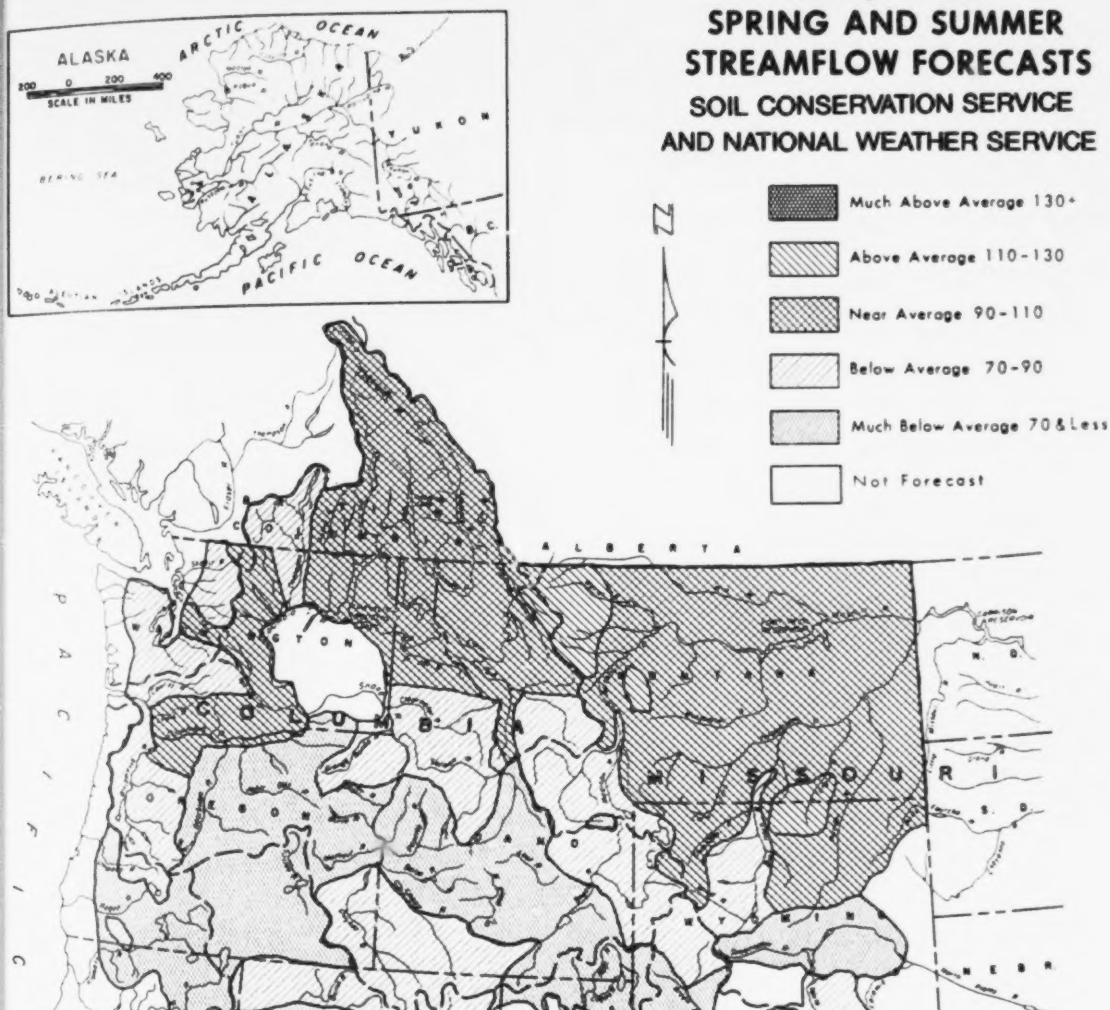
In February, streamflow forecasts showed less than 70 percent of average flows anticipated for the Colorado River Basin, the Sierra Nevada streams that feed reservoirs of the Central Valley Project in California, and the upper Snake River basin. Above average streamflow forecasts were largely limited to the upper Missouri River basin and portions of the Columbia River Basin.

As the season progressed, forecast conditions did not improve; in many areas, the predicted percentage of average flow became less and less. By April, it was clear that many reservoirs would not refill from the low levels of the end of the last season.

February 1, 1990

SPRING AND SUMMER STREAMFLOW FORECASTS

SOIL CONSERVATION SERVICE AND NATIONAL WEATHER SERVICE

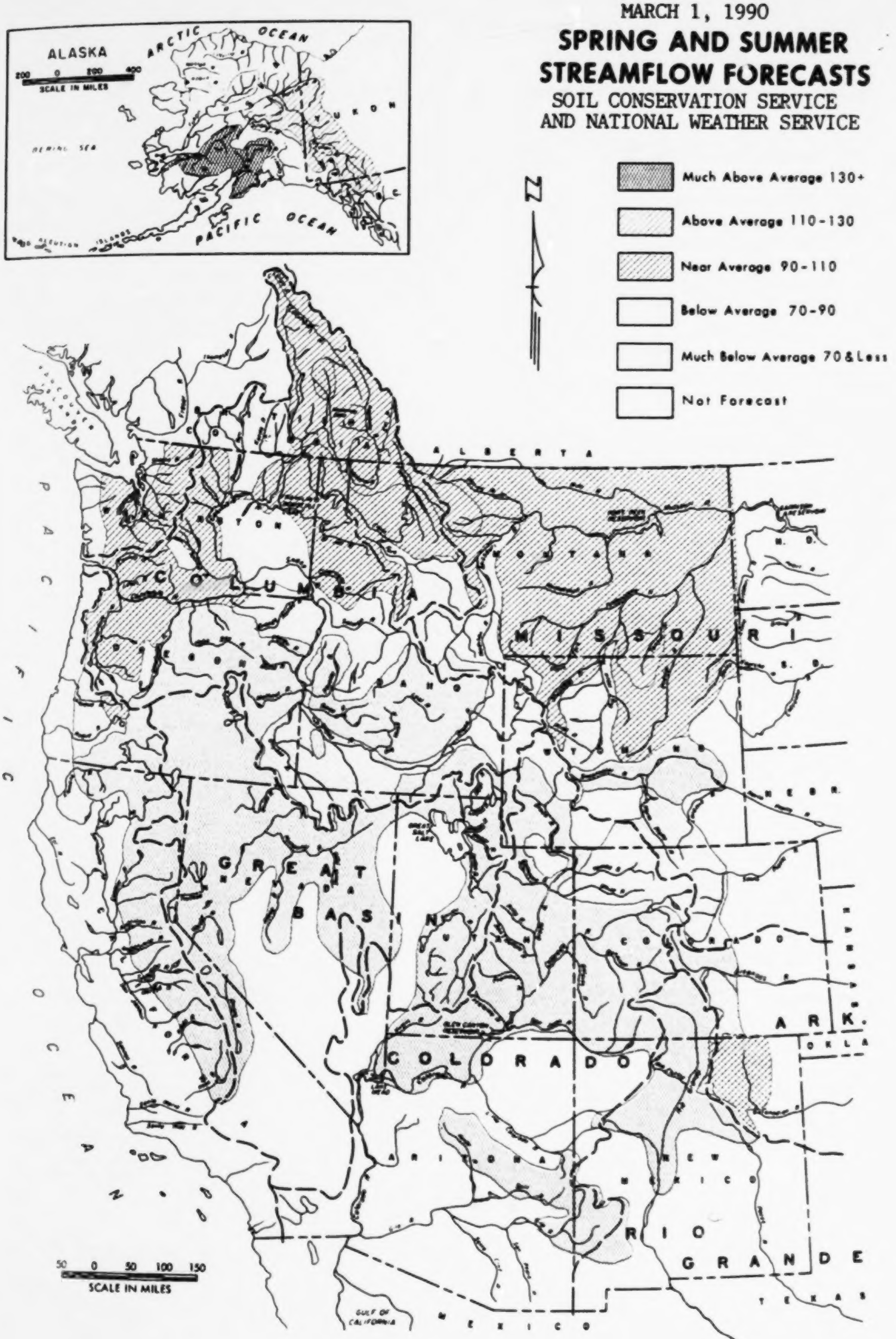


▩ Much Above Average 130+
▨ Above Average 110-130
▩ Near Average 90-110
▨ Below Average 70-90
▨ Much Below Average 70 & Less
☐ Not Forecast
N
ALASKA
ARCTIC OCEAN
200 0 200 400
SCALE IN MILES
YUKON
BERING SEA
B.C.
PACIFIC OCEAN
ALEUTIAN ISLANDS
ALBERTA
WASHINGTON
COLUMBIA
MONTANA
MISSOURI
N.D.
S.D.
OREGON
IDAHO
WYOMING
NEBR
GREAT BASIN
NEVADA
UTAH
GREAT SALT LAKE
COLORADO
KANSAS
ARK.
OKLA
COLORADO
ARIZONA
NEW MEXICO
RIO GRANDE
TEXAS
MEXICO
GULF OF CALIFORNIA
PACIFIC OCEAN
50 0 50 100 150
SCALE IN MILES

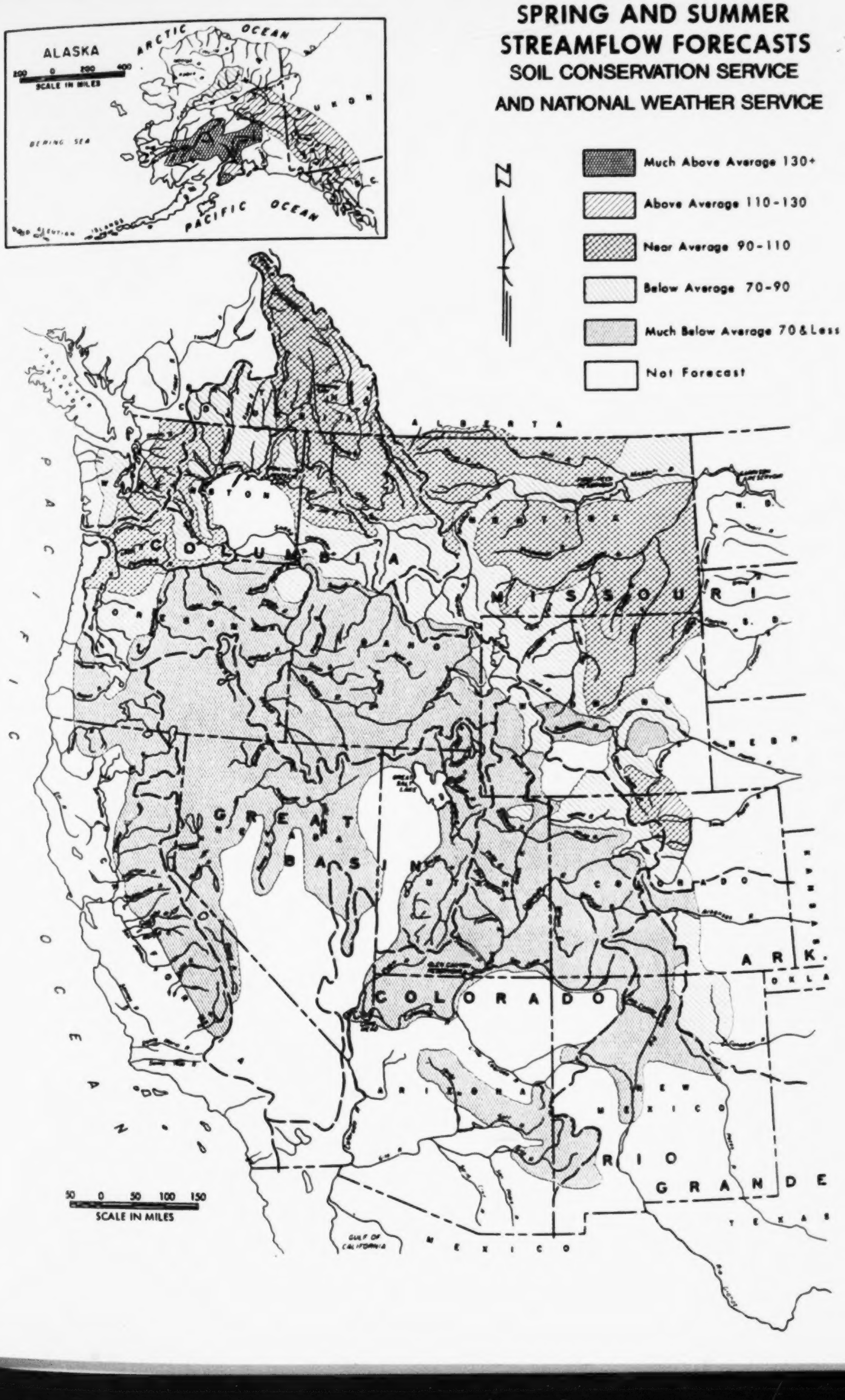
MARCH 1, 1990

SPRING AND SUMMER STREAMFLOW FORECASTS

SOIL CONSERVATION SERVICE
AND NATIONAL WEATHER SERVICE


ALASKA
200 0 200 400
SCALE IN MILES
ARCTIC OCEAN
BERING SEA
YUKON
B.C.
PACIFIC OCEAN
ALEUTIAN ISLANDS
N
Much Above Average 130+
Above Average 110-130
Near Average 90-110
Below Average 70-90
Much Below Average 70 & Less
Not Forecast
ALBERTA
PACIFIC OCEAN
WASHINGTON
COLUMBIA
OREGON
IDAHO
MONTANA
N. D.
MISSOURI
S. D.
WYOMING
NEBR.
GREAT BASIN
NEVADA
UTAH
GREAT SALT LAKE
COLORADO
KANSAS
ARK.
OKLA
ARIZONA
NEW MEXICO
RIO GRANDE
TEXAS
MEXICO
GULF OF CALIFORNIA
50 0 50 100 150
SCALE IN MILES

APRIL 1, 1990
SPRING AND SUMMER STREAMFLOW FORECASTS
SOIL CONSERVATION SERVICE AND NATIONAL WEATHER SERVICE


▩ Much Above Average 130+
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▨ Below Average 70-90
▨ Much Below Average 70 & Less
☐ Not Forecast
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ALASKA
ARCTIC OCEAN
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SCALE IN MILES
BERING SEA
YUKON
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PACIFIC OCEAN
ALEUTIAN ISLANDS
ALBERTA
WASHINGTON
COLUMBIA
MONTANA
N.D.
MISSOURI
S.D.
OREGON
IDAHO
WYOMING
NEBR
GREAT SALT LAKE
GREAT BASIN
NEVADA
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COLORADO
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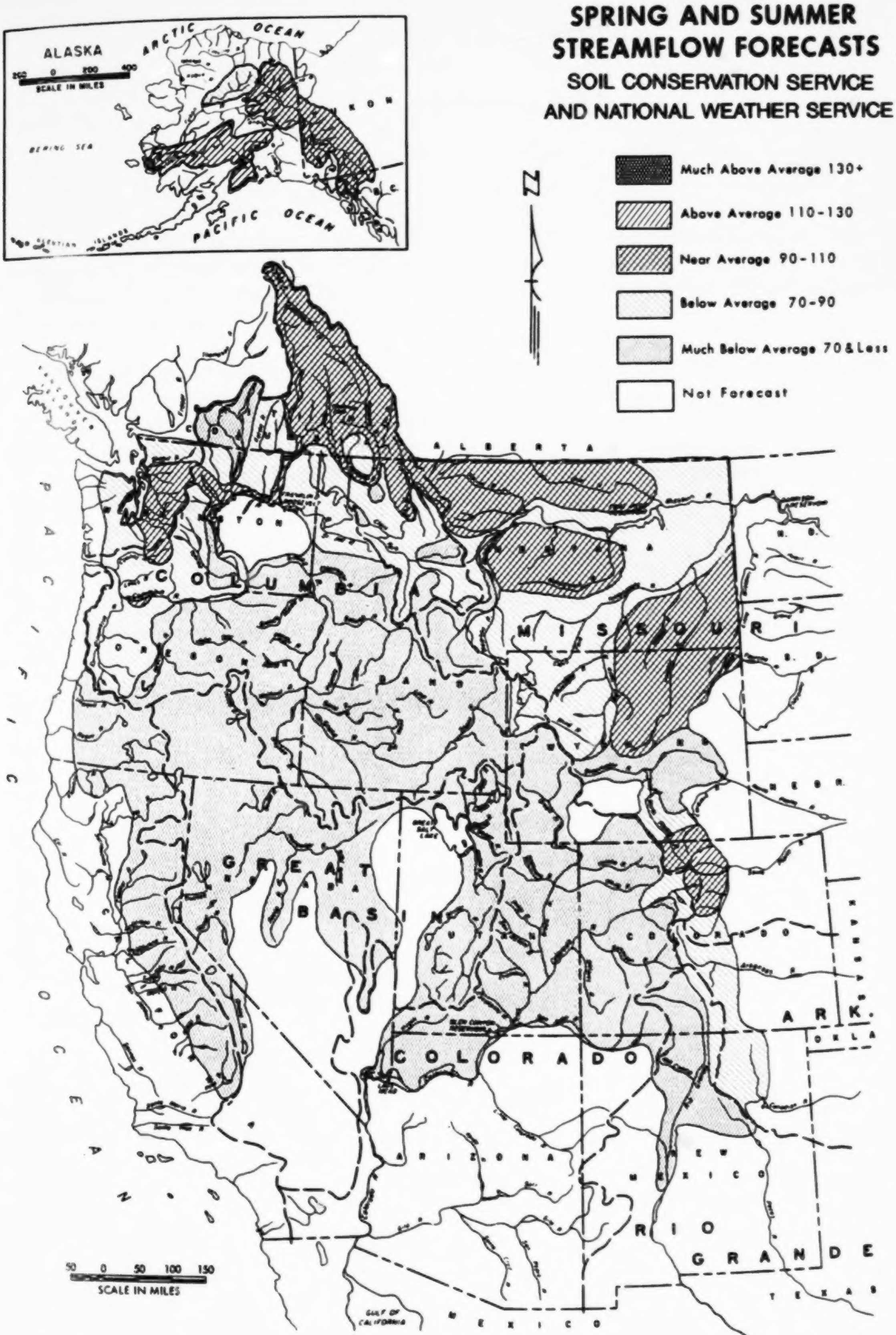
NEW MEXICO
RIO GRANDE
TEXAS
PACIFIC OCEAN
GULF OF CALIFORNIA
MEXICO
50 0 50 100 150
SCALE IN MILES

May 1, 1990

SPRING AND SUMMER STREAMFLOW FORECASTS

SOIL CONSERVATION SERVICE AND NATIONAL WEATHER SERVICE



ALASKA
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SCALE IN MILES
ARCTIC OCEAN
BERING SEA
PACIFIC OCEAN
YUKON
B.C.
ALEUTIAN ISLANDS
Much Above Average 130+
Above Average 110-130
Near Average 90-110
Below Average 70-90
Much Below Average 70 & Less
Not Forecast
N
ALBERTA
COLUMBIA
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MISSOURI
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OREGON
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COLORADO
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NEW MEXICO
RIO GRANDE
TEXAS
PACIFIC OCEAN
50 0 50 100 150
SCALE IN MILES
GULF OF CALIFORNIA
MEXICO

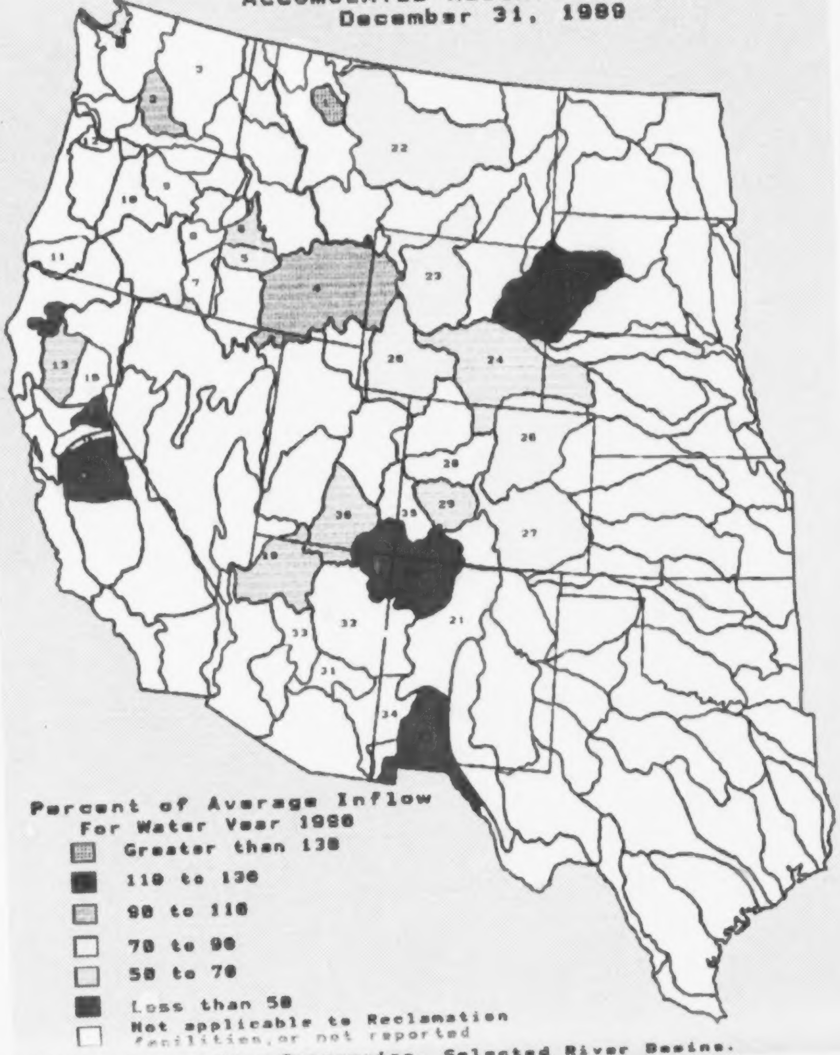
Accumulated Inflow

The accumulated inflow is the accumulated amount of water that has entered a reservoir to date. During the spring runoff season, much of this water is snowmelt. After the snowmelt runoff has subsided, inflow returns to base flow, which is maintained through natural streamflow from springs and other subsurface releases. Information about reservoir inflow allows reservoir operators to schedule reservoir releases to meet downstream requirements and, at the same time, hold back enough carryover storage for next year's needs.

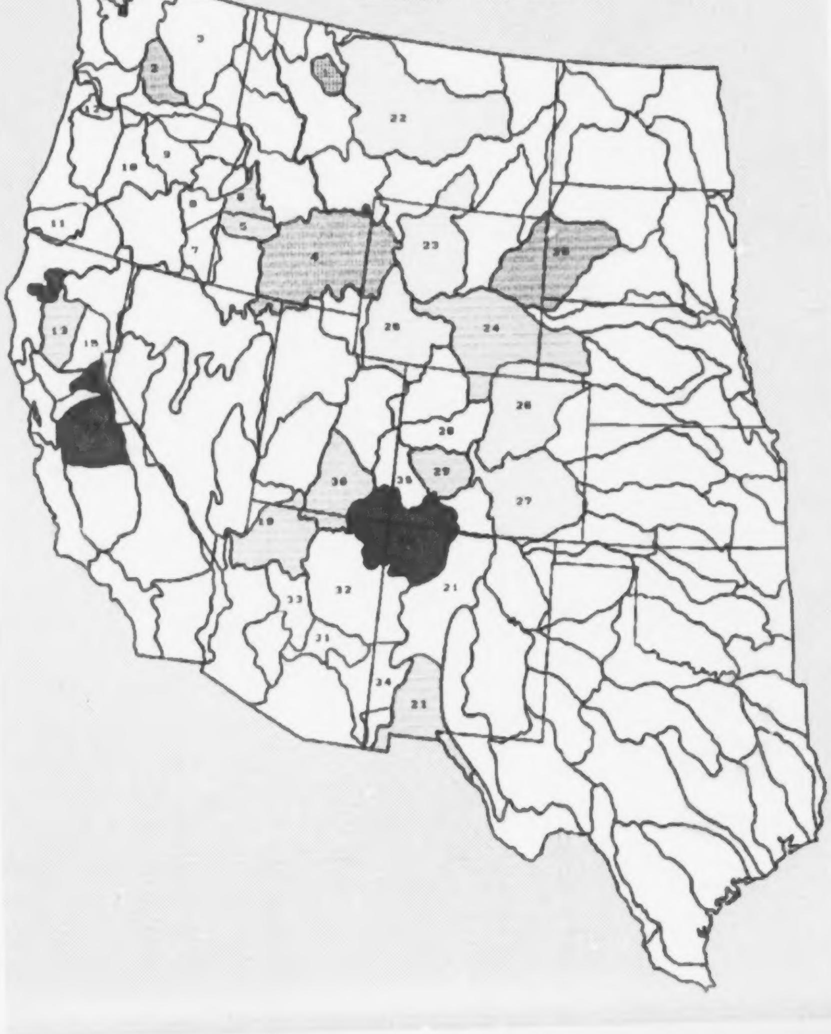
During drought, the amount of accumulated inflow to a reservoir is reduced and often requires a reduction in releases for downstream needs—a rationing of water. (Instantaneous inflow, the amount of water entering a reservoir at a particular point in time, is not the same as accumulated inflow. It is, nonetheless, an important measurement at some Reclamation reservoirs, where water deliveries in water-short years may be regulated by the instantaneous inflow on a particular date.)

During 1990, an early warming trend advanced the snowmelt; therefore, runoff peaked early and the accumulated inflow into many Reclamation reservoirs fell off earlier in the season than usual. By the end of June, reservoir inflow was severely below average in the Central Valley of California and in the Colorado River Basin.

ACCUMULATED RESERVOIR INFLOW
December 31, 1989

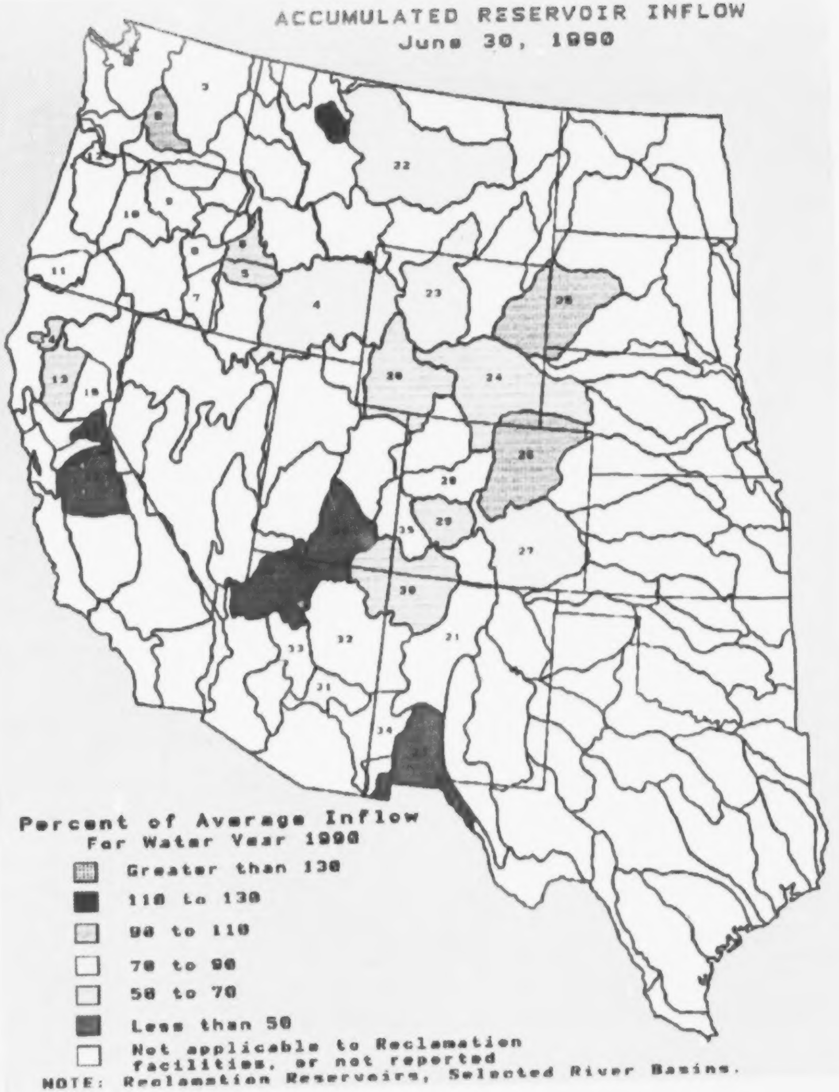

Percent of Average Inflow
For Water Year 1990
▨ Greater than 130
■ 110 to 130
▨ 90 to 110
☐ 70 to 90
☐ 50 to 70
■ Less than 50
☐ Not applicable to Reclamation facilities,or not reported

ACCUMULATED RESERVOIR INFLOW
March 31, 1990



NOTE: Reclamation Reservoirs. Selected River Basins.

ACCUMULATED RESERVOIR INFLOW
June 30, 1990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Percent of Average Inflow
For Water Year 1990
▩ Greater than 130
■ 110 to 130
▨ 90 to 110
☐ 70 to 90
☐ 50 to 70
■ Less than 50
☐ Not applicable to Reclamation facilities, or not reported

NOTE: Reclamation Reservoirs, Selected River Basins.

ACCUMULATED RESERVOIR INFLOW
September 30, 1990

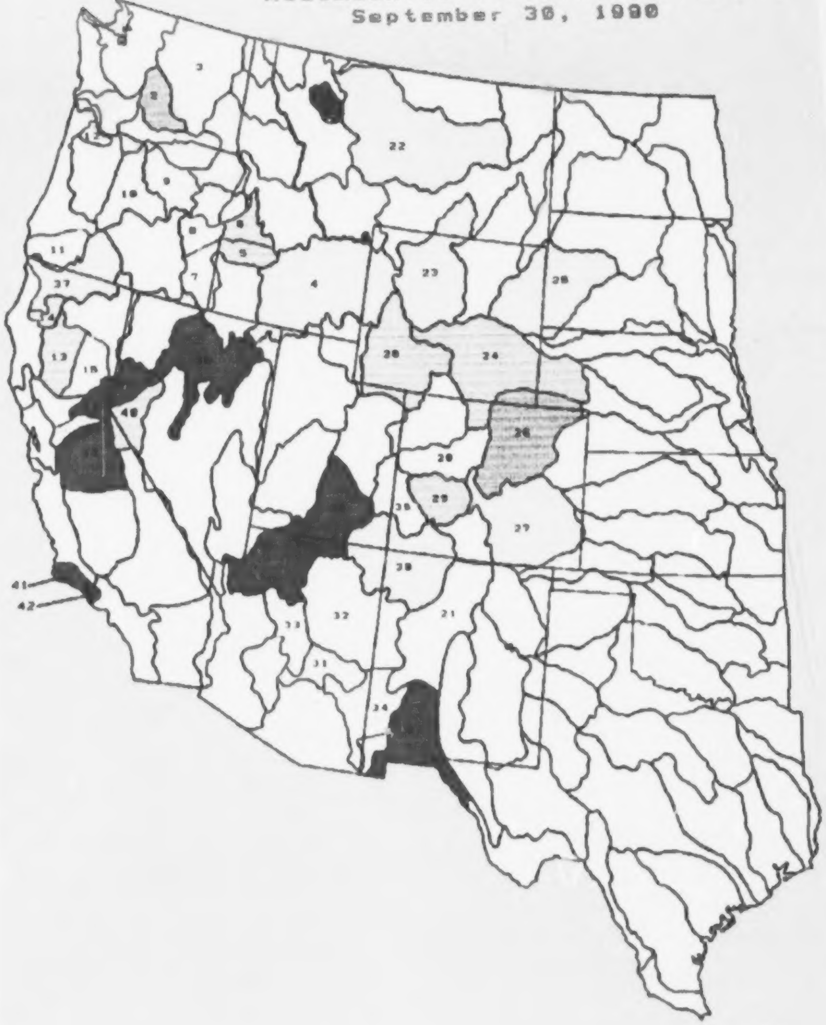
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Table 2
BUREAU OF RECLAMATION ACCUMULATED RESERVOIR INFLOW
SELECTED RIVER BASINS[1]

River Basin Number	Basin	December 31, 1989 Inflow	December 31, 1989 Percent of Average	March 31, 1990 Inflow	March 31, 1990 Percent of Average	June 30, 1990 Inflow	June 30, 1990 Percent of Average	September 30, 1991 Inflow	September 30, 1991 Percent of Average
1	South Fork Flathead	664	317	951	221	2,912	128	3,343	126
2	Yakima	582	101	1,372	96	3,033	99	3,384	97
4	Upper Snake	620	92	1,124	92	3,044	75	3,769	70
5	Boise	140	71	329	62	1,039	56	1,189	55
6	Payette	185	66	433	67	1,372	63	1,547	62
13	Sacramento	754	58	1,931	52	3,021	59	3,616	62
14	Trinity	99	45	347	48	691	55	721	54
16	American	248	43	669	38	1,032	39	1,344	45
17	San Joaquin	109	46	261	38	524	36	767	41
18	Stanislaus	128	70	237	45	352	35	481	42
19	Lower Colorado[2]	893	69	1,733	68	4,390	48	5,477	46
21	Lower Rio Grande	57	46	169	62	268	35	350	39
22	Upper Missouri	688	82	1,261	82	2,321	74	2,747	71

---

[1] Inflow in 1,000 acre-feet. Basin numbers correspond to numbers on maps.

[2] Inflow into Lake Powell only

BUREAU OF RECLAMATION ACCUMULATED RESERVOIR INFLOW
SELECTED RIVER BASINS - Table 2 continued

River Basin	December 31, 1989		March 31, 1990		June 30, 1990		September 30, 1990	
Number Basin	Inflow	Percent of Average	Inflow	Percent of Average	Inflow	Percent of Average	Inflow	Percent of Average
23 Bighorn	443	86	819	81	1,472	78	1,942	77
24 North Platte	16	57	139	69	488	56	1,052	56
25 Cheyenne	33	110	67	97	102	92	104	87
26 South Platte[1]	10	74	20	83	172	94	218	90
27 Arkansas[2]	63	78	120	81	299	71	427	80
28 Upper Green	106	80	233	83	677	55	930	56
29 Gunnison[3]	63	62	122	68	437	54	571	52
30 San Juan	42	49	86	46	439	65	612	71
36 Upper Colorado[4]	893	69	1,733	68	4,390	48	5,477	46
37 Klamath	N/A[5]	N/A	N/A	N/A	N/A	N/A	1,072	70
38 Humboldt	N/A	N/A	N/A	N/A	N/A	N/A	30	25
39 Truckee	N/A	N/A	N/A	N/A	N/A	N/A	129	27

---

[1] Includes Colorado River water inflow to Lake Granby which is the principal sources of supply for the Colorado-Big Thompson Project in the South Platte basin.

[2] Includes Fryingpan-Arkansas Project inflow.

[3] Inflow to Blue Mesa Reservoir

[4] Lake Powell inflow only.

[5] Not available

BUREAU OF RECLAMATION ACCUMULATED RESERVOIR INFLOW
SELECTED RIVER BASINS - Table 2 continued

River Basin Number Basin	December 31, 1989		March 31, 1990		June 30, 1990		September 30, 1990	
	Inflow	Percent of Average	Inflow	Percent of Average	Inflow	Percent of Average	Inflow	Percent of Average
40 Carson	N/A	N/A	N/A	N/A	N/A	N/A	212	57
41 Santa Ynez	N/A	N/A	N/A	N/A	N/A	N/A	3	4
42 Ventura	N/A	N/A	N/A	N/A	N/A	N/A	-.3	-1

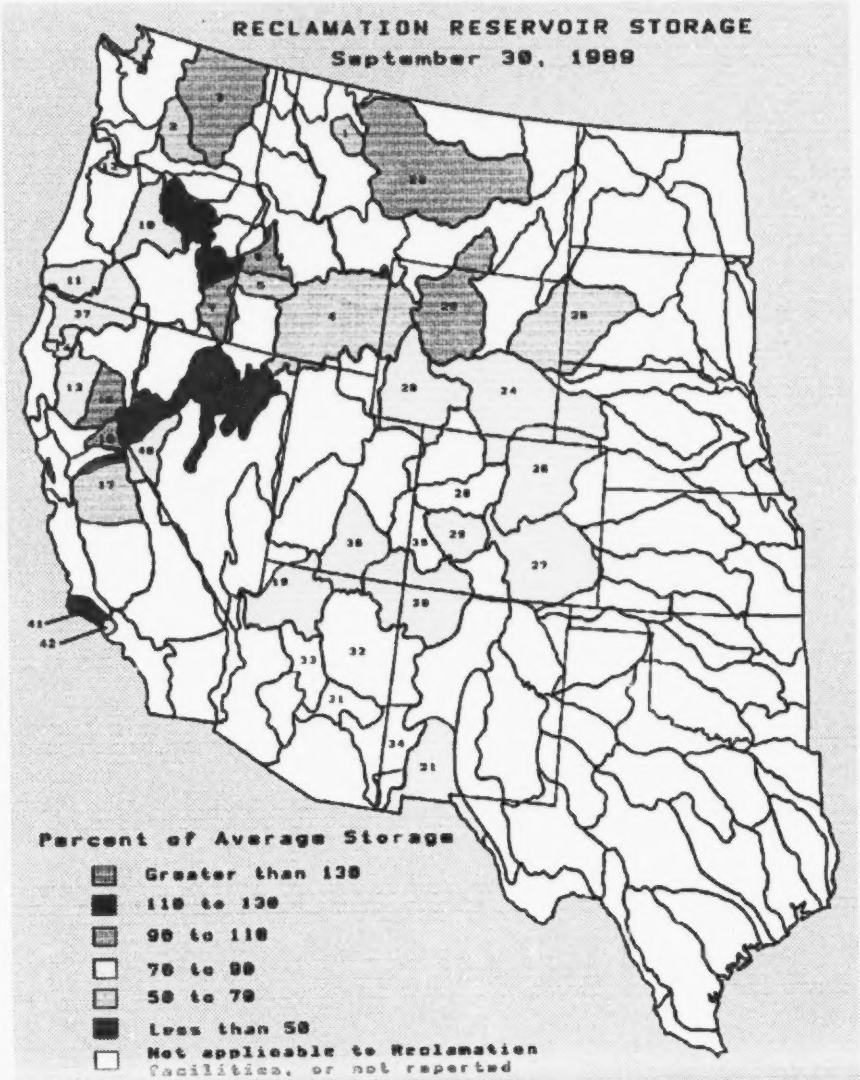
Reservoir Storage

Reservoir storage, for many projects, is the key to the adequacy of each year's water supply. The central task of Reclamation's reservoirs is to capture the spring runoff for release during the dry season. But, even under the best of conditions, a multitude of factors must be considered to balance reservoir storage with downstream water uses.

Many Reclamation reservoirs were authorized by the Congress to meet multiple water uses, and the requirements for each water use are balanced under the reservoir's operating plan. As pertinent, the operating plans answer the following questions: If carryover levels are high, how much will the reservoir need to be drawn down in the winter to capture possible spring floods? Will enough water be available to meet consumptive water requirements? How does the volume of water released from the reservoir compare to the volume of water flowing into it? If the winter snowpack is low, will there be enough water left in the reservoir pool at the end of the summer season to provide for next year's water requirements?

At the end of water year 1989, on September 30, 1989, Reclamation knew that carryover water supply in many reservoirs was dangerously low. However, the 1989-1990 winter precipitation was still uncertain. In the low storage areas, if winter precipitation was low, water supply would worsen; if precipitation was normal, water supply could be adequate; but, if precipitation was higher than normal, storage could be replenished while at the same time meeting water demands. The unknown factor--the amount of precipitation and hence the amount of reservoir inflow—would remain uncertain until well into the winter.

As the water year 1990 progressed, it became clear that water supplies would be inadequate to meet all water-user needs in some portions of the West. Of particular concern were areas of California, portions of the Colorado River basin, some subbasins in the upper Missouri River drainage, and in the central Snake River basin. The following maps trace the percent of normal reservoir storage as it appeared at the beginning of the water year, and at four more intervals until the end of the year on September 30, 1990.



RECLAMATION RESERVOIR STORAGE
September 30, 1989

Percent of Average Storage
▨ Greater than 130
■ 110 to 130
▨ 90 to 110
☐ 70 to 90
☐ 50 to 70
■ Less than 50
☐ Not applicable to Reclamation facilities, or not reported
NOTE: Selected River Basins.
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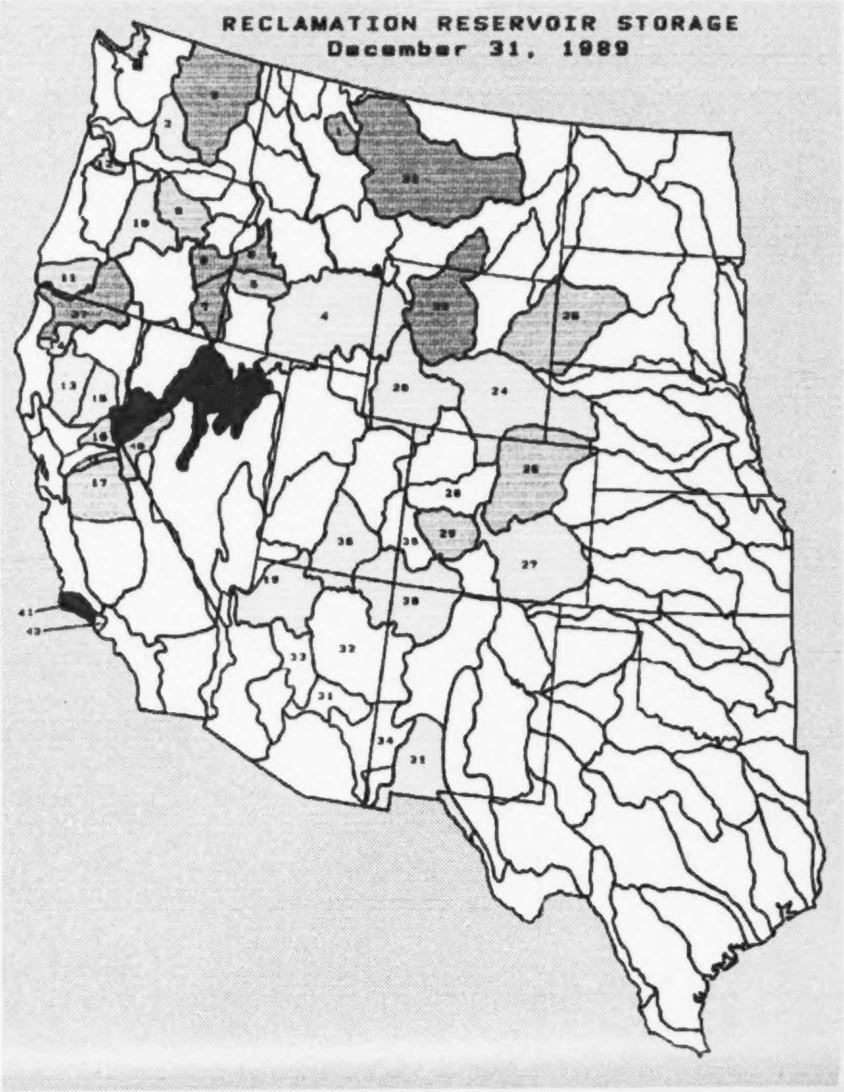
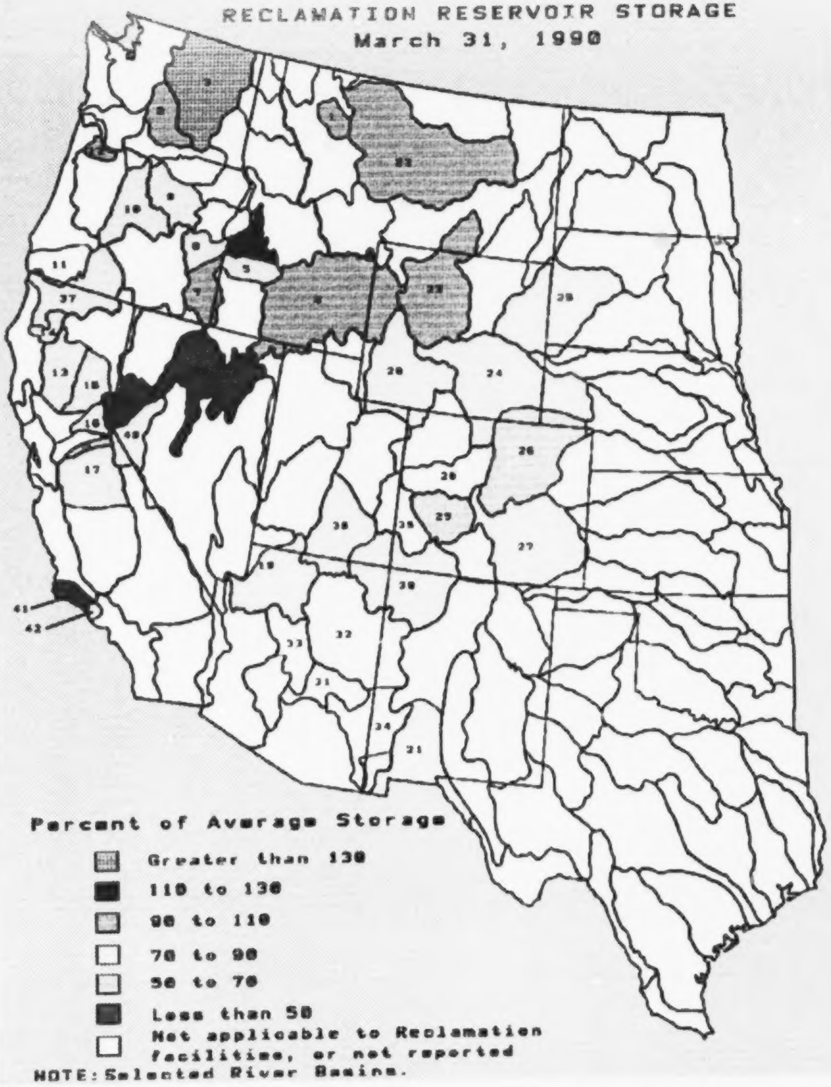
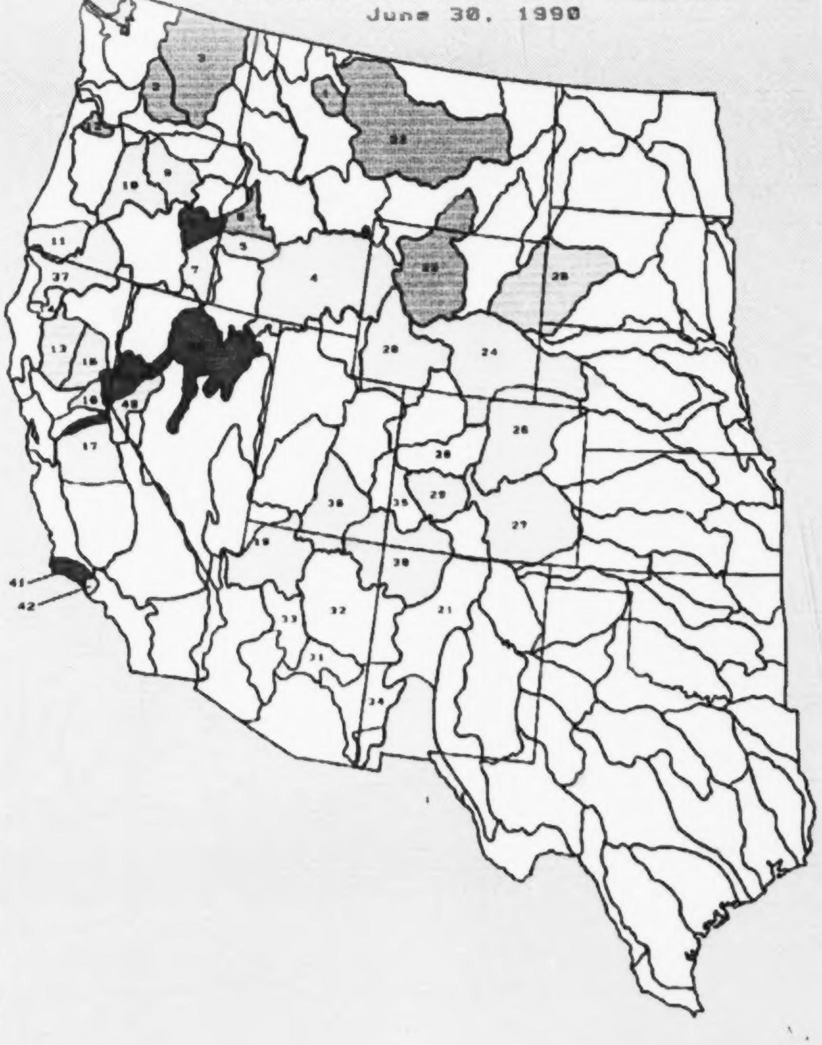


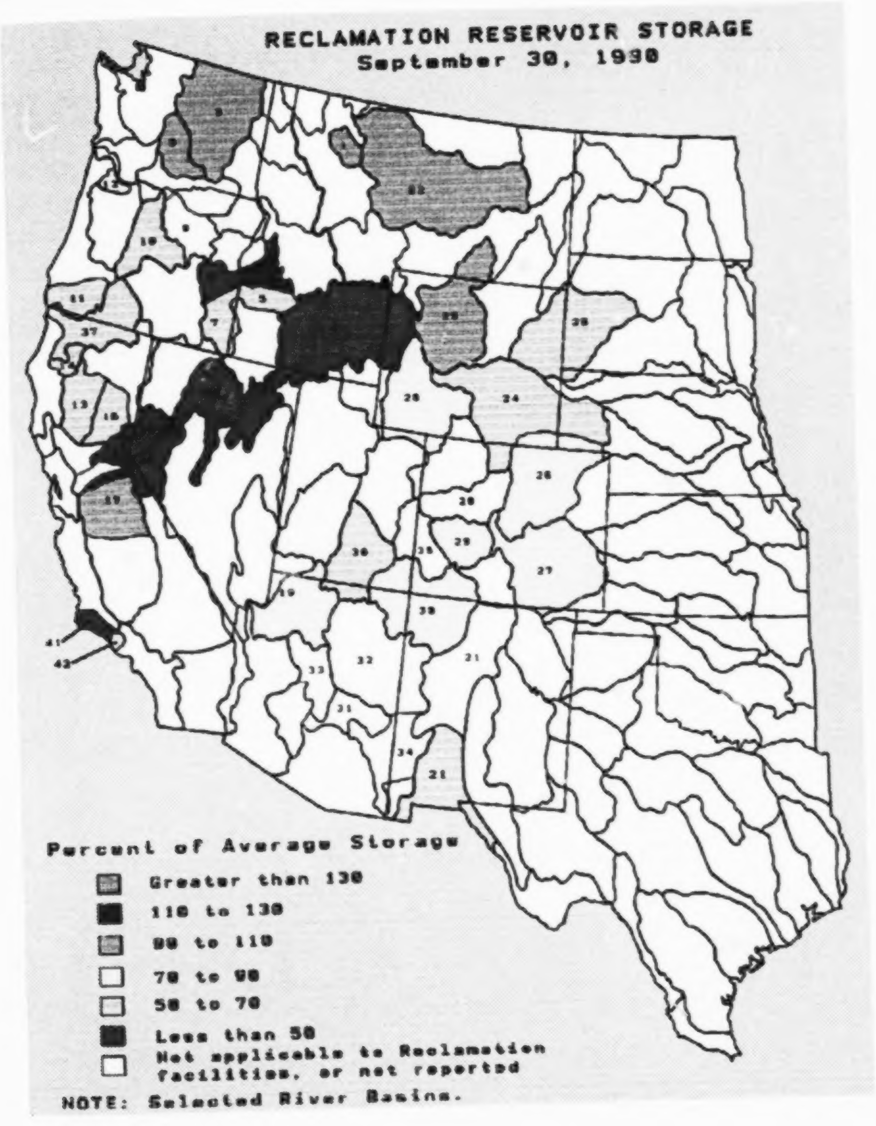
RECLAMATION RESERVOIR STORAGE
December 31, 1989

RECLAMATION RESERVOIR STORAGE
March 31, 1990


Percent of Average Storage
▨ Greater than 130
■ 110 to 130
▨ 90 to 110
☐ 70 to 90
☐ 50 to 70
■ Less than 50
☐ Not applicable to Reclamation facilities, or not reported
NOTE: Selected River Basins.

RECLAMATION RESERVOIR STORAGE
June 30, 1990




RECLAMATION RESERVOIR STORAGE
September 30, 1990
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Percent of Average Storage
Greater than 130
110 to 130
90 to 110
70 to 90
50 to 70
Less than 50
Not applicable to Reclamation facilities, or not reported
NOTE: Selected River Basins.

Table 3
BUREAU OF RECLAMATION RESERVOIR STORAGE SELECTED RIVER BASINS[1]

River Basin		September 30, 1989		December 31, 1989		March 31, 1990		June 30, 1990		September 30, 1990	
Number	Basin	Storage	Percent of Average	Storage	Percent of Average	Storage	Percent of Average	Storage	Percent of Average	Storage	Percent of Average
1	South Fork Flathead	1,710	63	2,078	94	1,720	103	2,835	99	2,670	98
2	Yakima	228	57	442	79	717	96	1,061	106	401	101
3	Columbia	5,646	100	5,799	108	4,390	191	5,507	99	5,590	99
4	Upper Snake	1,422	68	2,277	85	3,352	108	3,019	83	791	38
5	Boise	362	69	453	69	609	84	761	75	301	58
6	Payette	468	103	487	110	543	130	811	104	539	118
7	Owyhee	403	98	423	94	589	96	457	73	209	51
8	Malheur	105	124	119	107	158	80	85	43	0	1
9	Umatilla	19	126	22	54	69	70	73	81	N/A[2]	N/A
10	Deschutes	206	84	298	88	411	89	314	77	136	55
11	Rogue	59	78	62	69	N/A	N/A	90	73	38	50
12	Tualatin	21	74	17	58	51	104	52	106	25	86
13	Sacramento	2,096	77	2,054	72	2,709	73	2,358	69	1,637	64

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[1] Storage is expressed in thousands of acre-feet of water. One acre-foot is equivalent to about 326,000 gallons. The percentage of average storage refers to the average storage on that date over a historic period of record which varies by reservoir. Basin numbers correspond to numbers on the map.

[2] Not Available

BUREAU OF RECLAMATION RESERVOIR STORAGE
SELECTED RIVER BASINS - Table 5 continued

River Basin Number Basin	September 30, 1989 Storage	September 30, 1989 Percent of Average	December 31, 1989 Storage	December 31, 1989 Percent of Average	March 31, 1990 Storage	March 31, 1990 Percent of Average	June 30, 1990 Storage	June 30, 1990 Percent of Average	September 30, 1990 Storage	September 30, 1990 Percent of Average
14 Trinity	1,376	76	1,257	73	1,431	73	1,628	74	1,162	67
15 Feather	2,150	91	1,889	77	2,092	73	1,693	58	1,163	53
16 American	571	96	312	61	503	73	525	67	178	33
17 San Joaquin	140	66	163	61	250	76	317	82	183	90
18 Stanislaus	672	46	763	55	769	50	568	36	378	28
19 Lower Colorado[1]	23,365	82	23,650	83	23,725	84	22,557	80	22,177	78
21 Lower Rio Grande	2,124	79	2,139	79	2,114	78	1,942	72	1,743	65
22 Upper Missouri	2,336	94	2,442	100	2,304	101	2,890	102	2,478	99
23 Bighorn	1,896	93	1,854	102	1,637	102	2,047	92	1,846	90
24 North Platte	1,038	72	1,115	74	1,251	77	1,470	74	914	65
25 Cheyenne	163	56	199	62	257	75	283	67	160	56
26 South Platte[2]	499	74	416	67	412	69	637	81	513	77
27 Arkansas[3]	361	88	356	78	393	75	456	87	385	83

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[1] Percent of storage capacity, rather than percent of average.

[2] Includes Colorado River storage water for the Colorado Big-Thompson Project.

[3] Includes Fryingpan-Arkansas Project storage water

BUREAU OF RECLAMATION RESERVOIR STORAGE

SELECTED RIVER BASINS - Table 3 continued

River Basin Number Basin	September 30, 1989 Storage	 Percent of Average	December 31, 1989 Storage	 Percent of Average	March 31, 1990 Storage	 Percent of Average	June 30, 1990 Storage	 Percent of Average	September 30, 1990 Storage	 Percent of Average
28 Upper Green[1]	2,960	79	2,944	79	2,968	79	3,040	81	3,082	82
29 Gunnison[2]	585	71	563	68	576	69	680	82	618	75
30 San Juan[3]	1,310	77	1,231	73	1,179	70	1,367	81	1,361	80
36 Upper Colorado[4]	19,805	79	18,892	76	17,920	72	17,853	71	16,252	65
37 Klamath	503	87	581	91	774	86	667	77	357	63
38 Humboldt	20	22	12	11	35	30	13	10	5	5
39 Truckee	216	39	154	27	181	34	229	34	85	17
40 Carson	74	75	110	67	185	83	142	63	26	26
41 Santa Ynez	66	45	60	43	58	37	43	29	34	26
42 Ventura	169	78	160	75	156	70	149	68	138	67

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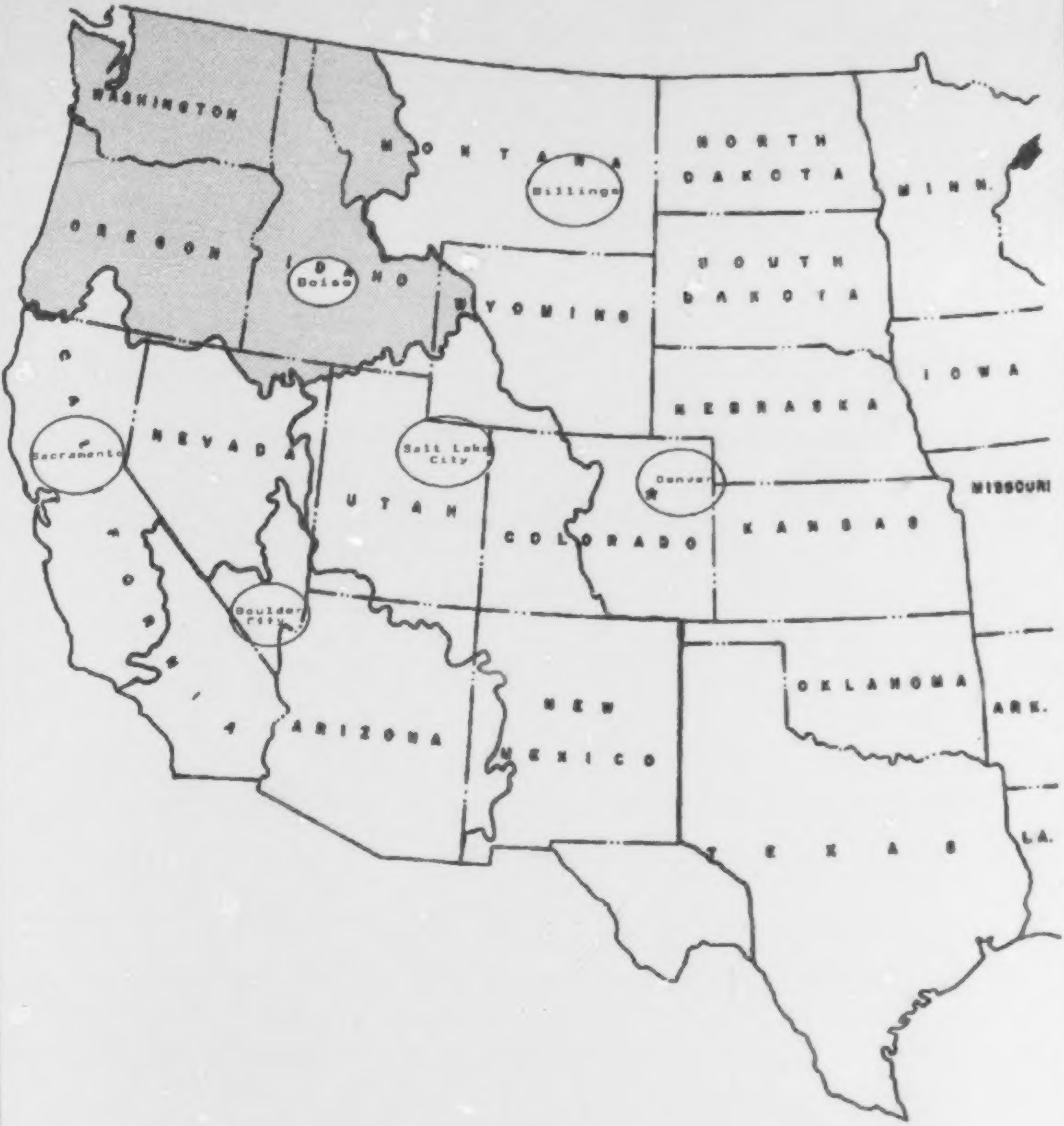
[1] Flaming Gorge Dam storage water. Percent of storage capacity rather than percent of average storage.

[2] Blue Mesa Dam storage water. Percentage represents storage capacity rather than average storage.

[3] Percent of storage capacity rather than percent of average storage.

[4] Lake Powell storage only. Percentage represents storage capacity rather than average storage.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OREGON
IDAHO
Boise
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Sacramento
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UTAH
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ARIZONA
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LA.

PACIFIC NORTHWEST REGION

JOHN W. KEYS, III, REGIONAL DIRECTOR
BOX 043-550 WEST FORT STREET
BOISE, IDAHO 83724-0043

PACIFIC NORTHWEST REGION

This chapter summarizes water year 1990 water supply conditions and Reclamation's response to drought conditions in the Pacific Northwest Region, focusing on those Reclamation projects with the most significant impacts from drought conditions during 1990. The Pacific Northwest Region includes the States of Idaho, Oregon, and Washington and portions of Montana and Wyoming. Basically, the region encompasses the drainage basin of the Columbia River and coastal Oregon and Washington Rivers.

In general, end of season carryover storage is below normal and below last year's volume in many projects within the region. Preliminary forecasts of 1991 water conditions are not available; Reclamation will begin to forecast the 1991 season runoff early in January 1991, when the first snowpack observations are made.

Boise Project, Idaho

The Boise Project consists of the Boise Division in the Boise River basin and the Payette Division in the adjacent Payette River basin.

Water Year 1990 Water Supply Conditions

Boise Division total storage was 361,900 acre-feet (68 percent of normal) at the beginning of the water year. A minimum winter flow of 150 ft^3/s was released after the irrigation season ended in mid-October 1989. Flows remained at minimum until late March 1990, when water was diverted into the New York Canal to begin refilling Lake Lowell, an offstream reservoir. By mid-April, the irrigation demands had increased, requiring discharges in excess of 3,000 ft^3/s. A peak demand of 4,000 ft^3/s was met during late June and early July. Overall, irrigation demand averaged about 80 percent of normal, indicating that farmers were conserving water.

Maximum Boise River system storage of 796,573 acre-feet (70 percent of capacity) was reached on June 14. Lake Lowell was intentionally drawn to a very low level at the end of the 1990 water year for construction of dam improvements. Total system storage at the end of the year was 300,800 acre-feet, 57 percent of normal, a very good carryover considering the poor water year and low beginning storage. Total 1990 natural runoff of the Boise River at Lucky Peak Dam was 1.19 million acre-feet, 55 percent of normal.

Following a careful irrigation operation, Payette River Division storage is 538,600 acre-feet (120 percent of normal), despite well below average runoff in 1990 of 1,547,000 acre-feet (62 percent of normal). In the Payette Division, total Reclamation storage on October 1, 1989, was 468,100 acre-feet (104 percent of average). Minimum flows of 200 ft^3/s were released at Cascade Dam until June 1, 1990, when irrigation demand began to exceed the downstream local inflows. No releases were made from Deadwood Dam until it filled and spilled, beginning June 12, 1990. Both reservoirs filled during June.

Releases to meet irrigation demand in the Payette River basin were made on order of the watermaster. Extra releases for power generation at Black Canyon Dam were not made during 1990.

Reclamation's Response to Drought Conditions

In the Boise River basin, Reclamation prepared an operating plan allowing for the orderly movement of water among basin reservoirs. The goals of the plan were to maintain power generation at Anderson Ranch Dam, protect instream flows for fish and recreation below Anderson Ranch Dam, and optimize recreation at Lucky Peak Reservoir. The operating plan provided a reasonable compromise among competing water uses. The Boise River Water Bank, in its second year of operation, helped transfer water from willing sellers to willing buyers.

In the Payette River basin, Reclamation worked with the State of Idaho to develop a water scheduling agreement among water users. The scheduling agreement improved the efficiency of water use and improved the reliability of water supplies to individual users. Reclamation and the State continued their organizational work in the basin in 1990, resulting in the formation of a water district and the appointment of a watermaster. A watermaster last controlled the basin during the severe drought of 1977. The new water district subsequently formed the Payette River Water Bank to help transfer water from willing sellers to willing buyers. The Payette River Water Bank is the third operating water bank in Idaho.

Minidoka Project, Idaho

Storage in seven project reservoirs totaled 1,417,700 acre-feet, 67 percent of average, at the beginning of the water year. The project was operated generally for conservation during the winter refill season, with some balancing of storage between Jackson Lake and Palisades Reservoir for flood control downstream of Jackson Dam. Flood stages did not occur. At one point, natural runoff at Hiese briefly exceeded 20,000 ft^3/s, officially activating a set of more restrictive flood control rule curves. But, no reservoir draft was undertaken, since the trigger flow was very brief and below normal runoff was predicted.

Maximum system storage was 3,557,100 acre-feet (88 percent of capacity) on May 2, 1990. Irrigation demand brought the storage down to 781,740 acre-feet at the end of September 1990, 37 percent of normal. American Falls Reservoir was empty in mid-September. Total runoff for the year at Hiese was 3.97 million acre-feet, 74 percent of normal.

Crooked River Project, Oregon

From October 1989 to mid-February 1990, the operational emphasis at Prineville Reservoir was maintaining the minimum required flood control space. During that period, most inflow was passed downstream. A small amount of storage (7,460 acre-feet) was allowed to accumulate, contrary to the flood space requirements, as a dry year seemed to be forming. In spite of apparent dry conditions, early season runoff forecasts indicated that the reservoir would probably fill sometime in April.

From mid-February, all possible inflows were stored while meeting a new minimum downstream fishery requirement of 75 ft^3/s from uncontracted storage water. In March, it became obvious that Reclamation's runoff forecast was unrealistically high, so the River Forecast Center projection was adopted for the basin. It still appeared that the reservoir would fill.

However, the dry spell continued, and a peak storage of 127,232 acre-feet, 83 percent of capacity, was reached in mid-April, the same time that irrigation demand began. The reservoir was drafted to meet irrigation demand for the rest of the water year, with a storage of 58,820 acre-feet (62 percent of normal) at the end of September—the second lowest end-of-year storage in the project's 30 year history.

Fill restrictions are in effect at Ochoco Reservoir because of safety concerns due to seepage observed in previous years. The reservoir outlets were closed during the winter and all inflow was stored. Very dry winter and spring conditions prevailed, and the reservoir never came near the allowed fill point, peaking at 16,118 acre-feet (35 percent of capacity, 54 percent of the restricted capacity) on April 19, 1990. Irrigation demand then drained the reservoir to 1,166 acre-feet, 8 percent of normal, by the end of September.

Tualatin Project, Oregon

Henry Hagg Lake storage at the beginning of the water year was 21,200 acre-feet, 40 percent of capacity and 76 percent of normal. The reservoir was further drafted during the fall to provide water quality flows downstream on the Tualatin River. The lake reached record low storage of 13,191 acre-feet on November 22. At that time discharge was reduced to 20 ft^3/s minimum flow, and storage began to accumulate. Discharge was reduced again to 10 ft^3/s beginning in December 1989.

Henry Hagg Lake filled on May 1, 1990, and was held full until June 20, 1990, when demand exceeded inflow. The pool has been steadily drafted through the summer, ending the water year with a storage of 24,590 acre-feet, 89 percent of normal.

Vale Project, Oregon

Water Year 1990 Water Supply Conditions

Drought conditions in the Pacific Northwest Region seemed to be the most severe in eastern Oregon, particularly in the Malheur River basin. Storage in three Reclamation reservoirs totaled 104,600 acre-feet (136 percent of normal) at the beginning of the water year. However, runoff of the Malheur River above Beulah Reservoir for the year was only 45,800 acre-feet, 42 percent of normal. The Vale Project experienced its second year of far below-normal water supplies; reservoirs were essentially empty by mid-August 1990.

A conservation operation was followed to store all possible inflows until irrigation demand began in April. Peak system storage of 159,490 acre-feet (57 percent of capacity) was observed on April 6. Demands were then met until August 19, when storage was totally depleted. Storage at the end of the water year totaled 500 acre-feet—effectively empty.

Reclamation's Response to Drought Conditions

Reclamation continued a program begun in 1989 to help the Vale Irrigation District establish a water measuring system to identify areas of excessive loss in the system. Once high-loss areas are identified, conservation measures can be studied to improve efficiency. Reclamation has also discussed with the district institutional constraints that may hamper efficient water use.

Hungry Horse Project, Montana

Reclamation operates Hungry Horse Reservoir for flood control, power, recreation, and fisheries. On October 1, 1989, the active storage was 1,224,000 acre-feet, 41 percent of capacity. The storage was stable until November, when unusually high streamflows began, filling the reservoir to 72 percent of capacity by the end of January. The reservoir was drafted for flood control, reaching its lowest level in mid-April. The reservoir started to fill according to flood control criteria; it filled July 15, 1990. By September 30, 1990, the reservoir had been drafted to 2,670,000 acre-feet (90 percent of capacity).

The peak observed inflow of 28,934 ft^3/s occurred on November 12, 1989, and the maximum outflow was 15,083 ft^3/s on June 13, 1990. A kokanee (landlocked salmon) spawning flow of at least 3,500 ft^3/s was provided at Columbia Falls for the entire year.

Grand Coulee Project, Washington

Grand Coulee Dam is operated for flood control, power, irrigation, recreation, fisheries, and navigation. On October 1, 1989, Roosevelt Lake (impounded by Grand Coulee Dam) was at elevation 1287.1 feet, 2.9 feet from full, 95 percent of capacity. It was operated between 1290.0 and 1284.0 feet until the middle of February. The annual drawdown of Roosevelt Lake began in the middle of February with outflows of about 120,000 ft^3/s. The lake continued drafting for flood control and "water budget" (downstream fish migration) flows until May 23, 1990. The reservoir was again full at the end of July. On September 30, 1990, the lake was at elevation 1286.3 feet, 3.6 feet from full and 94 percent of capacity. The maximum daily inflow was 227,500 ft^3/s on June 26, 1990, and the maximum daily outflow was 212,900 ft^3/s on June 13, 1990.

Yakima Project, Washington

Water Year 1990 Water Supply Conditions

The Yakima system reached maximum storage for the year on June 9, 1.07 million acre-feet, and was put on storage control on July 4. All water users received a full water supply in 1990. The carryover on September 30, 1990, was 401,080 acre-feet, very near normal.

Operating data indicate that the October 1989 through July 1990 unregulated runoff for the Yakima River (at Parker) was 3.3 million acre-feet—about 93 percent of normal. During September and October 1989, the upper Yakima reservoirs were operated to enhance anadromous fish (salmon and steelhead) spawning conditions; from October to May the reservoirs were operated to provide incubation and rearing flow levels. During this period, Reclamation released 48,500 acre-feet of storage to meet anadromous fish needs. All 1989-90 incubation flow releases were made from Lake Cle Elum.

The "flip-flop" operation was executed for the tenth consecutive year. Spawning flows are provided for spring chinook salmon under a court order. In 1990, the "flip-flop" operation began September 5, and flows were stabilized and verified by September 10. Spawning flows were set at 200 ft^3/s in the Yakima River below Easton Dam and at 150 ft^3/s in the Cle Elum River below Cle Elum Dam.

The "flip-flop" operation involves drawing storage from Keechelus, Kachess, and Cle Elum Reservoirs to meet all Yakima River diversions in June, July, August and the first few days of September. During these months, storage from Rimrock Reservoir and Bumping Lake is used only to meet the Naches and Tieton River diversions. In September, when low river flows are required in the Yakima River from Easton to the mouth of the Teanaway, reservoir releases meet only the spawning flow levels. Also, about 350 ft^3/s is routed around the Easton to Teanaway reach via the Kittitas Canal spillway. Requirements for the Yakima system below the confluence of the Naches River, as well as the Naches and Tieton diversions, are met with releases from Tieton Reservoir and Bumping Lake.

Reclamation's Response to Drought Conditions

Although water supplies were near normal in 1990 on the Yakima Project, the project experienced below normal supplies for most of the 1980's. To manage for water shortages, Reclamation implemented a variety of measures to extend and conserve supplies.

In 1989, Reclamation completed a reconnaissance analysis of the Kittitas Reclamation District to identify ways to improve system operations and reduce water losses. In 1990, Reclamation began working with the district to develop a water measuring system. Data from the system will help identify areas of water loss and help evaluate opportunities for improving water delivery operations.

Reclamation continues to assist Yakima project irrigation districts that wish to consolidate and thereby conserve water through more efficient operations. For example, Reclamation assisted with the potential consolidation of four small irrigation districts in the Naches area west of Yakima. Before the plan can be implemented, members of the affected irrigation districts must vote on the proposal and resolve institutional barriers. Likewise, institutional issues must be addressed before implementing a plan to serve lands in the Moxee area east of Yakima with gravity pressure pipelines from the Roza Canal. Reclamation helped the Roza Irrigation District assess the plan.

Reclamation's "flip-flop" operation in the Yakima River basin helps conserve water resources by forcing anadromous fish to spawn at lower river flows. With the operation, reservoir storage is not required to keep the redds (fish nests) moist. Without the operation, spawning takes place at higher flows, leaving redds above the water surface level if flows are reduced. To avoid elimination of that year's hatch, higher reservoir releases would be required without the operation.

Other Reclamation Response Activities to Drought Conditions

Reclamation's Pacific Northwest Region initiated and participated in a variety of programs and activities to help reduce the impact of water shortages. One of the most significant is the Hydromet system, which provides data on reservoir storage, streamflow, weather conditions, and snowpack. Hydromet was originally developed under flood control authorities, but the information it provides is also useful for assessing water supply conditions and forecasting water supplies. Data collected through Hydromet is available to the States and other Federal agencies through the Corps of Engineers' Columbia River Operation Hydromet Management System.

In a cooperative effort with Bonneville Power Administration and electric utilities, Reclamation uses the backbone of the Hydromet system (satellite telemetry and a computer database) to operate the AgriMet system in the Pacific Northwest. AgriMet, a network of remote agricultural weather stations linked to a computer in Boise, Idaho, provides daily estimates of consumptive water use for local crops. Irrigators use the information to schedule irrigation for greatest efficiency and effectiveness, thus reducing water use and improving crop quality and quantity. Crop water consumption estimates are also published in local newspapers.

Interest in AgriMet continues to grow, and cooperative partnerships have developed with many Federal, State, and local agencies. For example, Reclamation has provided facilities to Washington State University's Public Agricultural Weather System (PAWS) and is working to integrate six PAWS stations into the AgriMet network. Reclamation is also working to add one station in Idaho and three stations in Montana to AgriMet.

Idaho Response Activities

Prompted by critical water supplies, the State of Idaho convened its Data and Water Supply Committees in January. The Data Committee prepared a report with water supply information supplied by Reclamation, the Soil Conservation Service, the National Weather Service, the Geological Survey, and the Idaho Department of Water Resources. The Water Supply Committee then provided this information to irrigators, cities, recreationists, sportsmen, businessmen, and others. The Water Supply Committee also provided information on Federal and State programs available to mitigate the impacts of water shortages.

Reclamation participated at all meetings of the Data and Water Supply Committees. Reclamation also provided information on Reclamation programs for the State drought report and provided information on proposed amendments to the 1988 drought legislation.

Southeastern Idaho experienced critical water supplies in 1989, but storage from the upper Snake River system helped reduce impacts from water shortages. And, while water conditions in 1990 were still below normal, the available water supply improved from 1989, allowing Reclamation to increase instream flows slightly above 1988 and 1989 levels. Reclamation's Minidoka Project Office continued to meet regularly with irrigation managers and to provide information to help water users wisely manage available water supplies. Reclamation also provided tips on water conservation.

Areas of south-central Idaho experienced the most critical water supplies in 1990. Early forecasts projected an extremely short water supply for Magic Reservoir and the Big Wood River basin. Magic Reservoir is not a Federal project, and none of the Big Wood River basin irrigation facilities were developed under Federal programs. The Big Wood River basin irrigation facilities are relatively inefficient, but irrigators cannot afford to make significant improvements. Reclamation offered, through the Idaho Department of Water Resources, to help irrigators improve their operations with Federal loans. However, the irrigators were unable to take advantage of the offer.

Oregon Response Activities

Oregon's Water Availability Committee helped assess the State's water supply conditions. Reclamation did not attend Committee meetings because Reclamation is not a member, but Reclamation did provide some basic data used in the water supply analysis as well as the proposed amendments to the 1988 drought legislation. Reclamation also reviewed and commented on rules to implement Oregon drought legislation.

Although all portions of the State of Oregon were affected by drought in 1990, Reclamation projects in central and eastern Oregon were especially water-short. Reclamation took a variety of actions to deal with water shortages.

Reclamation began a study this year on the Gem Irrigation District of the Owyhee Project. The study seeks to reduce distribution system losses through a program of lining major canals and providing gravity pressure pipelines to irrigators.

Reclamation helped lay out and design a water measurement system for the Baker Valley Irrigation District. Data from this system helps the district better manage its water supply.

The Wapinitia Project in central Oregon historically has been water short; low water supplies in recent years have added to the problem. As part of its Investigation of Existing Projects program, Reclamation sought opportunities for reducing losses, changing operations, and enhancing supplies. Information about these opportunities was provided to water users.

Reclamation conducted a reconnaissance study of water savings opportunities in the Talent Division of the Rogue River basin in southwest Oregon in 1989. In 1990, Reclamation began an expanded initiative under its Global Climate Change Response Program. The current program seeks to enhance operation of the irrigation system by developing and using two computer models: one to predict irrigation requirements and another to predict water availability in the distribution system.

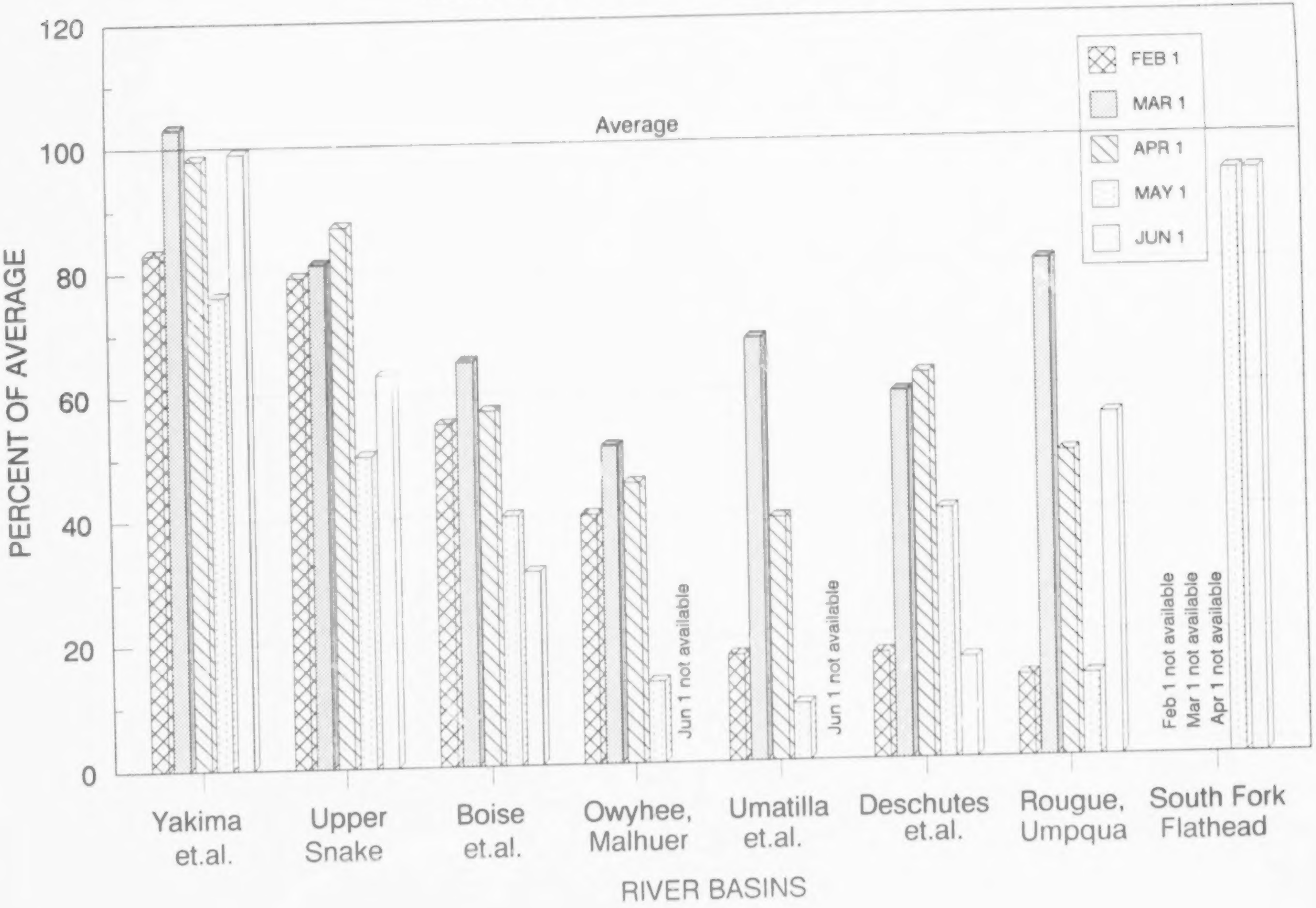
Washington Response Activities

Because water supply conditions in Washington were normal or near normal, the Washington Water Availability Committee conducted monthly conference calls instead of regular meetings. Reclamation participated in these conference calls.

Reclamation participated with the State of Washington in a water conservation assessment of the Walla Walla River basin. Under the Technical Assistance to States program, Reclamation examined conditions and operation and maintenance of the main irrigation conveyance and distribution systems. In its report, Reclamation identified and evaluated opportunities for structural and nonstructural improvements that would reduce irrigation diversions. The report quantified the water savings of each potential improvement and provided a basis for deciding which improvements to pursue.

Water Year 1990 Snow Water Equivalent

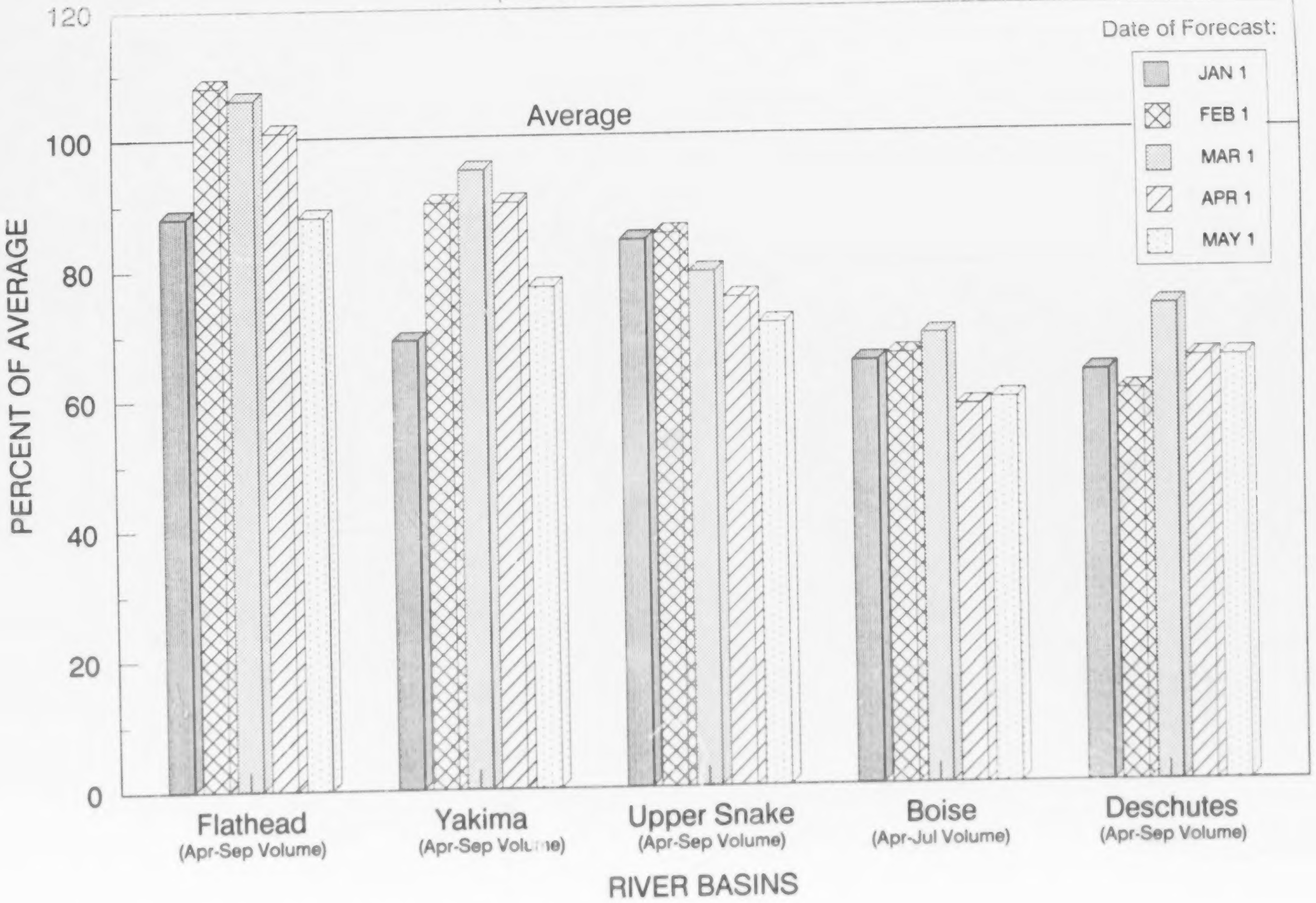
Trends for Pacfic Northwest Region



Pacific Northwest Region

Water Year 1990 Streamflow Forecasts[1]

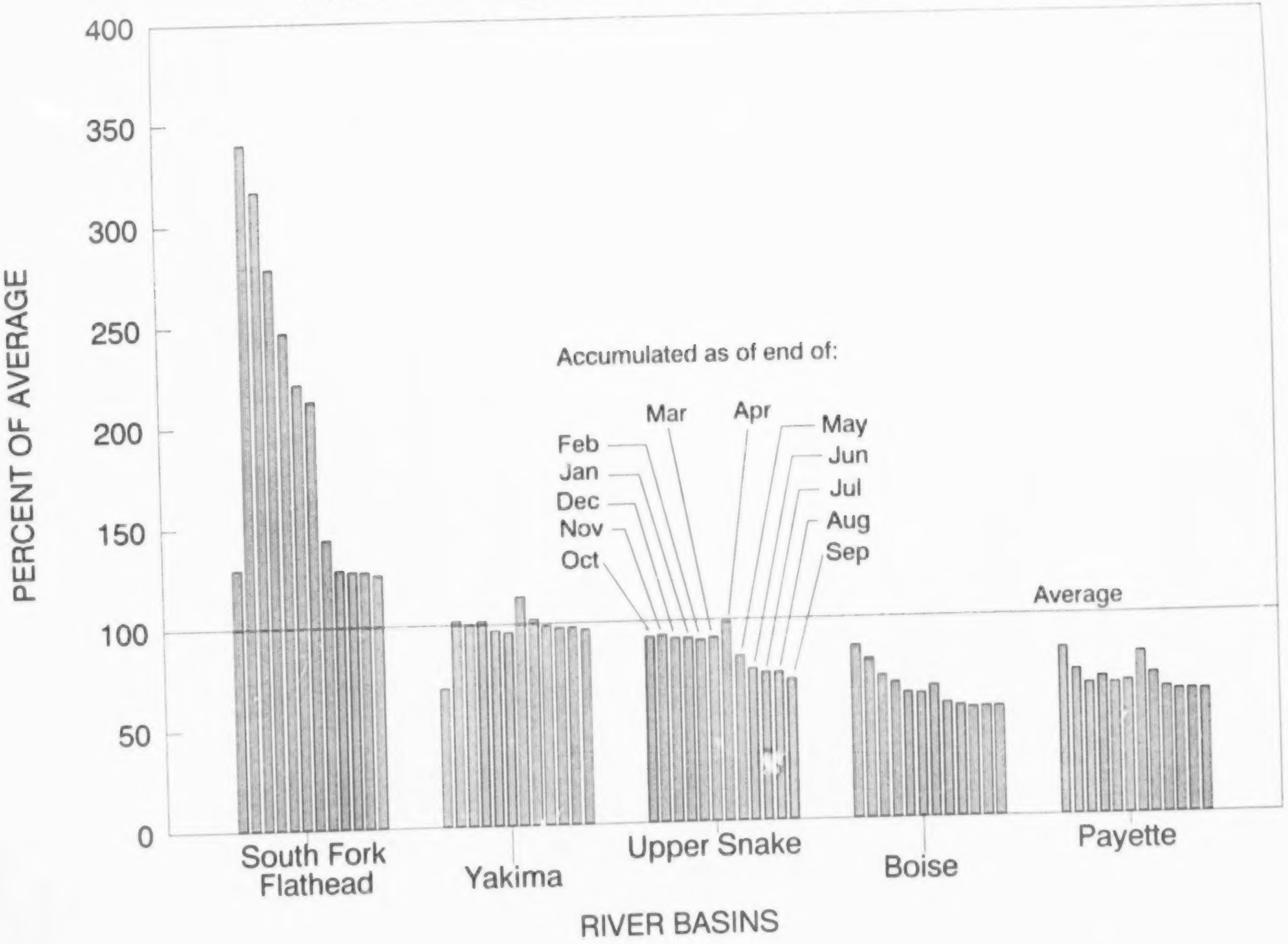
(Review Of What The Forecasts Were)



Note: 1. Data Source: "Water Supply Outlook For The Western U.S." By The Soil Conservation Service and National Weather Service

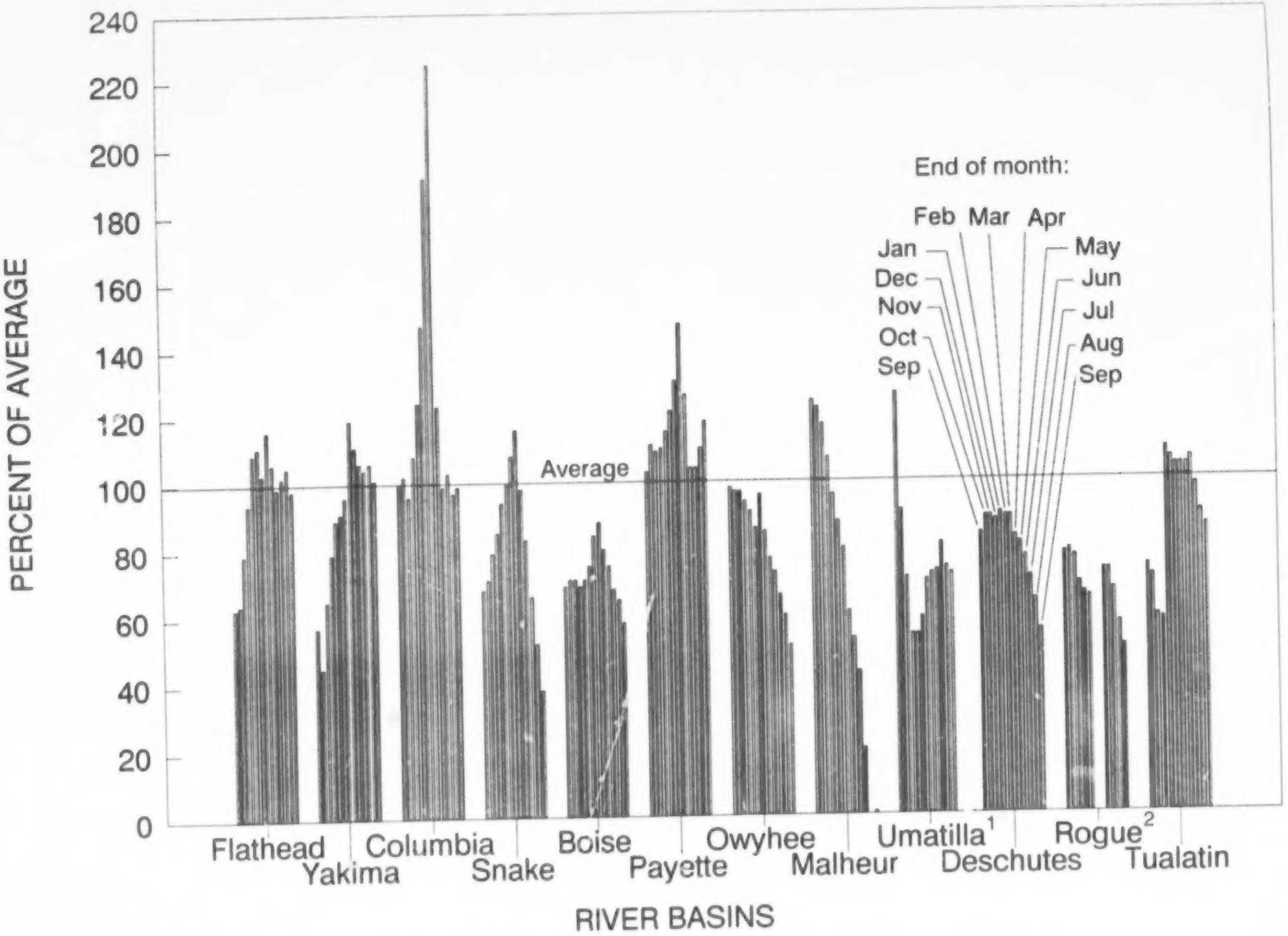
Water Year 1990 Accumulated Inflows, Pacific Northwest Region

Percent of Average, October 1, 1989 to September 30, 1990

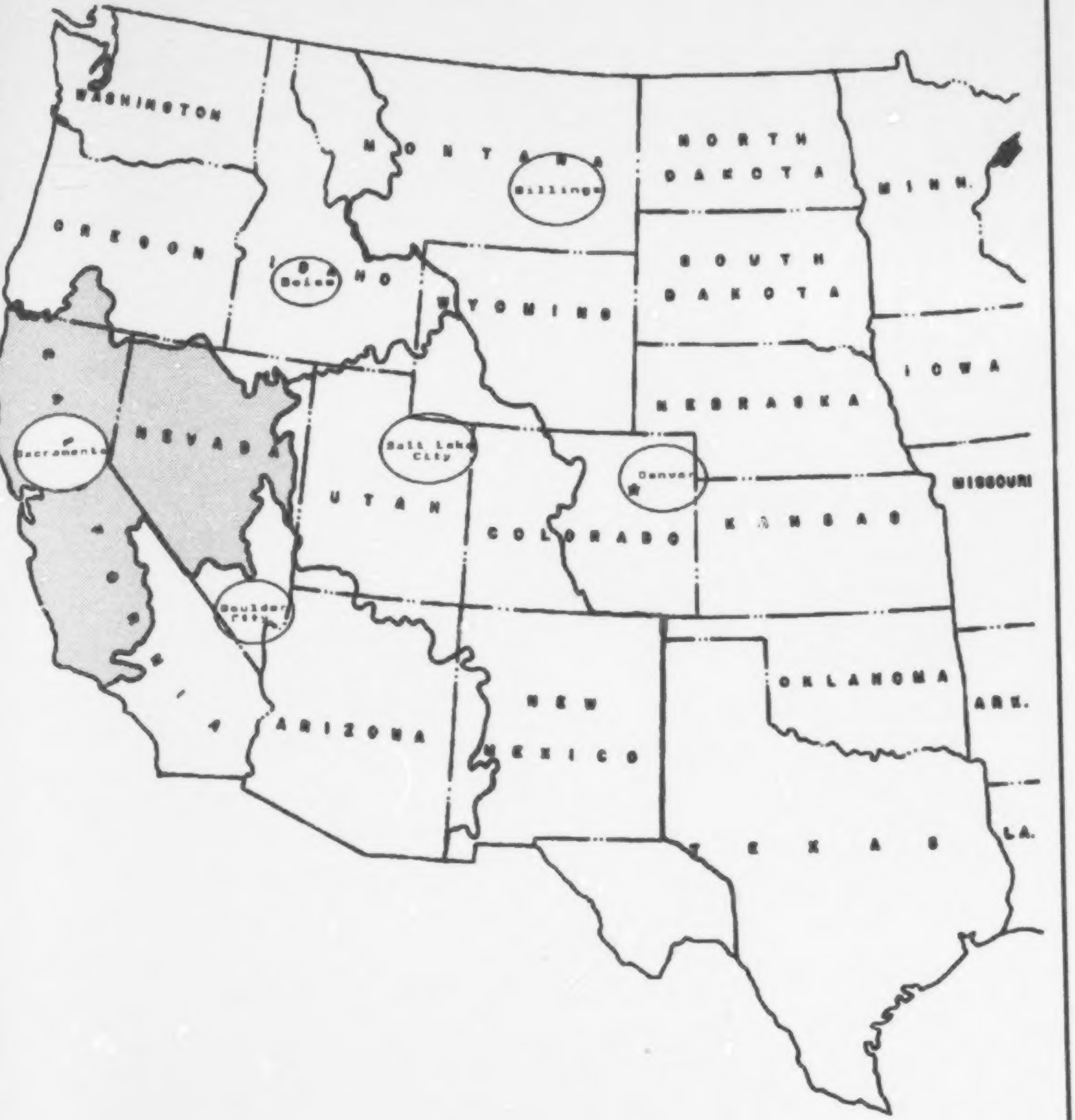


Water Year 1990 Reservoir Storage, Pacific Northwest Region

Percent of Average, September 30, 1989 to September 30, 1990



Notes: 1. Data for September 1990 not availiable for Umatilla 2. Data for March and April not availiable for Rogue



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MID-PACIFIC REGION
LAWRENCE F. HANCOCK, REGIONAL DIRECTOR
2800 COTTAGE WAY
SACRAMENTO, CALIFORNIA 95825-1898

MID-PACIFIC REGION

This chapter summarizes water year 1990 water supply conditions, Reclamation's response to drought, and projected water year 1991 operations in the Mid-Pacific Region. The Mid-Pacific Region includes most of California and portions of Nevada and Oregon. Projects include the Central Valley Project in California and other smaller projects on streams originating in the Sierra Nevada, lower Cascade, and southern California mountain ranges.

Central Valley Project, California

Water Year 1990 Water Supply Conditions

Early Optimism.—Water year 1990 began with indications of a possible end to the then 3-year-old drought in California. Strong storms occurred in late September and October 1989. Storage in major Central Valley Project (CVP) reservoirs was 5.1 million acre-feet, up 0.5 million acre-feet from the previous year. The CVP had averted water shortages over most of the project in 1989 by virtue of an extraordinarily wet March. This improved the water supply sufficiently to restore full deliveries while slightly improving carryover storage by the aforementioned 0.5 million acre-feet. By late October 1989, it appeared that there was a high probability for full water deliveries in 1990. Unfortunately, the outlook then began to worsen steadily.

Return to Severe Drought.—The 6-month period November 1989 through April 1990 (the normal rainy season in California) produced only a few moderate rain storms interspersed with prolonged periods of dry weather. The entire month of December 1989 passed without rain throughout most of the Central Valley—an unprecedented occurrence. In February, CVP water contractors and water rights holders served by the CVP were informed of impending shortages in their 1990 water supplies. Most contractors were cut to 50 percent supplies, and water rights entities were cut to 75 percent of full supply. Conservative forecasts with a 90-percent chance of being exceeded were used to allocate deficiencies. As generally dry weather persisted in February, March and April, actual conditions validated the conservative forecasts for water supply. By May 1, 1990, conservative forecasts showed CVP storage dropping to 2.9 million acre-feet in order to support even the deficient water deliveries committed to earlier by Reclamation.

Relief from Wet May of 1990.—Then came the "miracle May" of 1990. Two series of storms, the second (and larger) over Memorial Day weekend, produced by far the greatest reservoir inflows of the entire water year. These storms resulted in the wettest May of record at many locations in California, including Shasta and Trinity Dams.

Inflow from the May storms dramatically modified the water supply forecasts at a time of year when they are usually already accurately established. Reclamation restored all water rights entities to 100-percent supplies, as required by their agreements. The CVP also made about 83,000 additional acre-feet available to wildlife refuges. Agricultural and municipal and industrial contractors received no additional supplies, however, unless they qualified under Mid Pacific Region's stringent "hardship" criteria. Otherwise, all additional water accruing from the May 1990 storms became part of CVP carryover storage which at 3.98 million acre-feet, was over 1 million acre-feet more than Reclamation's May 1, 1990, expectations. Although the added reservoir storage was still far less than desirable, it undoubtedly aided the CVP's temperature control operations on the Sacramento River, and also prevented what otherwise would have been a prolonged violation of the CVP's Project Dependable Capacity. With only about 50 percent of desirable carryover storage, however, the CVP is again at risk of deficiencies in 1991.

Water Supply Situation for Individual Central Valley Basins.—The CVP has its major storage reservoirs five separate stream basins, plus its off-stream facility—San Luis Reservoir. With the exception of Friant Dam on the San Joaquin River, these reservoirs are generally operated as an integrated unit. System-wide water supply is often more significant than individual water supplies for determining CVP water delivery capabilities. The CVP has now experienced four consecutive dry years. At the beginning of this period, in late 1986, all CVP reservoirs were at desirable "seasonal" full levels. Since then, storage has decreased each year at New Melones (Stanislaus River) and Clair Engle (Trinity River). Folsom (American River) and Shasta (Sacramento River) had modest recoveries in 1989, followed by severe decreases in 1990.

System storage is at its lowest since 1977. New Melones and Clair Engle Reservoirs have little chance to refill in 1991 from their present storages. New Melones is at significant risk of falling below minimum power head in 1991. Because of the meager amount of carryover storage (3.98 million acre-feet), CVP water deliveries in water year 1991 will be depend mostly on runoff, rather than on stored water. In 1990, 1.1 million acre-feet was withdrawn from storage to help meet water demands. Stored water also permitted full deliveries to be made in 1987 and 1988, critically dry years.

In an average year, 1,400,000 acre-feet of Class 1 (firm supply) and Class 2 (nonfirm) water is released from Millerton Lake (impounded by Friant Dam on the San Joaquin River) to the Friant-Kern and Madera Canals. In water year 1990, available water supply was 743,000 acre-feet or 41 percent of the average, providing only 68 percent of Class 1 water. For the fourth straight year, no

Class 2 water was available. Consequently, additional ground-water pumping was required, resulting in a decrease of ground-water levels. Due to high pumping costs, marginal lands were idled and permanent crops were irrigated with just enough water for crop survival. The impacts to fish and wildlife are unknown.

The downward trend in CVP carryover storage from 1986 through 1990 is indicated by the following end-of-year storage numbers: 8.4 million acre-feet (1986), 6.3 million acre-feet (1987), 4.6 million acre-feet (1988), 5.1 million acre-feet (1989), and 4.0 million acre-feet (1990).

The four water years—1987, 1988, 1989 and 1990—constitute one of California's most severe droughts of this century. Water year 1989 was classified a "below normal" year, the other three water years 1987, 1988 and 1990 were "Critical" years under California's Sacramento River Index classification.

Natural runoff during the four year period 1987 through 1990 is the lowest for this century in the basins above New Melones, Friant, and Folsom Dams. CVP-wide, only the droughts of 1928-34 and 1976-77 are even comparable in their severity. Continuation of the present drought through 1991 could well constitute a "critical period" for the operation of the CVP: more severe than those used to determine the yield and other capabilities of the project.

Reclamation's Response to Drought Conditions

To cope with the fourth year of drought, Reclamation established a Drought Coordination Team to serve as a clearinghouse and as a source of drought information. When the February water supply forecast necessitated the declaration of shortages to all CVP contractors, Reclamation took the following measures to conserve and optimize available water supplies:

- Reclamation sent letters urging maximum conservation efforts to every contractor.

- Reclamation allowed contractors flexibility in scheduling deliveries (within the actual conveyance capabilities of the project).

- Reclamation asked its project offices to avoid unnecessary water use. For example, an investigation to monitor leakage in San Justo Reservoir was deferred because it would require additional CVP water.

- The Corps of Engineers allowed Reclamation, in cooperation with affected diverters, to operate the Sacramento River at less than the historical 5,000 ft^3/s navigation requirement.

- Reclamation allowed CVP facilities to be used to convey and store nonproject water to supplement reduced project supplies.

best copy available

- Reclamation hastened approvals for CVP agricultural and municipal and industrial water transfers and exchanges between irrigation districts.

In April, Reclamation adopted hardship criteria for irrigation and urban water users for the 1990 water year. Protection of health and safety and preservation of permanent crops were used as guidelines to evaluate requests for hardship water. Reclamation approved six requests for a total of 1,425 acre-feet of water.

In June, Reclamation issued 1990 water-transfer guidelines in conjunction with the notice to CVP Sacramento River water rights contractors and San Joaquin River exchange contractors that they would receive a 100-percent water supply because heavy May rains had increased inflow to Shasta Lake. Supplies in excess of contractors' needs were also made available for transfer according to the guidelines for hardship water. A total of 69,275 acre-feet of water was transferred.

Also in June, the Sacramento River Temperature Task Force completed an operation plan to provide cooler water temperatures for winter-run chinook salmon. Under the plan, water normally released through turbines at the Shasta powerplant was released through the low-level outlet to provide cooler water temperatures in the upper Sacramento River. Cooler temperatures were achieved with lower than anticipated bypasses because of favorable weather conditions and lower demands. Temperature objectives were also established for the fall-run spawning in October and November. The bypass operation began on July 14, 1990, and ended October 15, 1990, with an estimated $2 million in foregone generation.

Demands on Folsom Reservoir created low water levels that were less than optimum for recreation. Consequently, Reclamation and the California Department of Parks and Recreation developed more accessible swimming beaches and made food concessions and portable restrooms more accessible to recreationists. However, the lower reservoir storage also allowed dam safety work to be completed earlier than expected. Low water conditions permitted compaction of the dam foundation and construction of an upstream berm to increase the stability of Mormon Island Dam during seismic activity. Along with this work, construction material was excavated from the Folsom Lake Marina area at Browns Ravine. The excavation will greatly extend future use of marina facilities.

Because of severe water shortages in the Stanislaus River basin, measures have been taken to conserve dwindling storage in the basin's New Melones Lake. Reclamation and the South Delta Water Agency agreed to relaxed water quality objectives in the San Joaquin River at Vernalis to minimize releases from New Melones Lake for salinity control.

In response to water-shortage conditions in the Friant Division, operational procedures have been altered since 1987-88, and will again be altered next year.

Water districts are being allowed to carry over remaining 1990 water supply balances into the 1991 contract year. Numerous water transfers were approved among the districts. In addition, special permission has been obtained to enter into Warren Act Contracts with the districts or individual landowners during the 1990 water year to allow nonproject water to be pumped into Reclamation facilities--the Friant-Kern Canal, San Luis Canal, and Mendota Pool--for conveyance to the districts by Reclamation.

Projected Operations for Water Year 1991

Early analyses of water supply possibilities for 1991 indicate that full deliveries for CVP contractors will probably require normal or greater runoff. The distribution of runoff throughout the CVP will have a bearing on project capabilities because of the varying refill potential and localized operational requirements at each reservoir. In general, normal runoff during 1991 evenly distributed over the project reservoirs will support full water deliveries, plus provide some refill of carryover storage. Therefore, only normal or drier water supply scenarios are currently being analyzed in detail.

Preliminary operations forecasts have been performed for water year 1991 using three levels of water supply: "median," "dry," and "critical." These projections demonstrate that there is a significant risk of continuing severe drought conditions and water supply deficiencies in 1991. Depending on the severity of conditions, which at this time can only be cast in terms of historical water supply probabilities, operation of the CVP in water year 1991 could stretch project capabilities to their limits. The results of these studies are presented in the following table to illustrate their overall impact on CVP reservoirs.

Total reservoir storage projections
Central Valley Project
(million acre-feet)

9/30/90	Projected 9/30/91 Storage		
Storage	"Median"	"Dry"	"Critical"
3.98	5.6	4.0	3.2

Notes:

1. "Median": annual inflows 50th percentile, water deliveries 100 percent to water rights and other contractors.
2. "Dry": annual inflows 30th percentile, water rights deliveries, 100 percent, agricultural contracts deliveries, 75 percent.
3. "Critical": annual inflows 10th percentile, with 75-percent deliveries to water rights and 50 percent to agricultural contractors.

Lahontan Basin Projects

Project reservoir storage for the Truckee, Carson, and Humboldt Rivers at the beginning of the 1990 water year, in October 1989, ranged from 21 to 131 percent of normal. Water year 1990 streamflow at selected stations ranged from 25 to 55 percent of normal. Project reservoir storage currently ranges from 0 to 76 percent of normal.

The Soil Conservation Service streamflow forecast for May 1, 1990, for selected gaging stations on the Truckee, Carson, and Humboldt Rivers ranged from 14 to 30 percent of normal. Above average precipitation in May resulted in higher streamflow than forecast. The precipitation at Tahoe City, California, and Boca Dam, California, during May was 250 percent and 150 percent of normal, respectively.

Record precipitation in Fallon, Nevada, during April (2.30 inches or 550 percent of normal) significantly reduced that month's Newlands Project demand. Lahontan Reservoir releases were shut off for 1 week following this rain. In March, the Truckee-Carson Irrigation District (TCID) set the Newlands Project water allocation at 65 percent of entitlement but later revised the allocation to 70 percent based on improved conditions. In order to improve the delivery system efficiency, TCID delayed the beginning of releases from Lahontan until

March 28, 1990, and suspended releases from September 18 to October 15. The late season deliveries will be completed by the end of October 1990.

The Pershing County Water Conservation District initially set the Humboldt Project water allocations at 25 percent of entitlement but later adjusted the allocation to 27.5 percent. Above normal precipitation in April (3.37 inches at Rye Patch Dam) helped to conserve storage. Rye Patch Reservoir releases were shut off for approximately 1 week following this rain.

The level of Lake Tahoe fell below its natural rim outlet to the Truckee River on September 14, 1990, the eleventh time this has occurred since 1900. In addition to 7 consecutive years of during the 1930's drought, the lake also dropped below the rim in 1961, 1977, and 1988.

To conserve storage water during 1990, effective May 30, 1990, the Truckee River Floriston rate through September (court decreed flow rate at Farad, California) was reduced from 500 to 400 ft^3/s by agreement of all the water users. This reduced rate was maintained until August 25, when storage available to maintain Floriston rates was depleted. As part of the agreement to reduce the Floriston rate, on May 30, the Reno-Sparks, Nevada, area limited outside watering to twice a week.

For the third consecutive year, flows of the lower Truckee River were insufficient for spawning by the endangered Pyramid Lake cui-ui. During these years, Stampede Reservoir storage has been conserved for future cui-ui spawning; the amount currently available is 76 percent of normal. If Truckee and Carson River basin runoff is at least 100 percent of normal in 1991, the current Stampede storage along with expected repayment of Stampede water delivered to the Newlands Project in 1988 should be adequate to supplement the flows of the lower Truckee River as needed for cui-ui spawning. However, because Pyramid Lake is currently at elevation 3805 feet, the size of the spawning run may be constrained by limited access to the Marble Bluff Fish Facility, requiring use of the Pyramid Lake fishway in lieu of the river trap at Marble Bluff Dam.

In August 1990, 2,000 acre-feet of uncommitted Prosser Creek Reservoir water not needed for the Tahoe-Prosser Exchange Agreement was transferred temporarily to Boca Reservoir. That water will be transferred to Stampede Reservoir for use in the management of the cui-ui as soon as there is sufficient inflow to Stampede Reservoir to complete the transfer.

The Newlands Project and the Reno-Sparks, Nevada, area should not have shortages in 1991 if the runoff of the Truckee and Carson Rivers is at least 100 percent of normal. Runoff of the Humboldt River will need to be at least 120 percent of normal in 1991 in order to avoid shortages on the Humboldt Project.

Klamath Project, California

Klamath Project water users experienced no water shortages this water year, and the irrigation districts did not implement special measures to cut back on irrigation use.

However, because inflow to Upper Klamath Lake dropped substantially during the summer, on August 1, 1990, releases at Iron Gate to the Klamath River were restricted. However, the restrictions were lifted in September because of rain and cooler temperatures. The unusually large annual flow through Upper Klamath Lake gives Reclamation the flexibility to control lake elevations to protect irrigation supplies. Consequently, irrigation shortfalls are not expected next year, although under drought conditions, releases to the Klamath River again could be restricted. Likewise, storage at Clear Lake Reservoir indicates that no irrigation shortfalls will occur next year, even if drought conditions continue.

Stony Creek Basin, California and Nevada

On October 1, 1989, at the beginning of a fourth year of below normal rainfall, the Stony Creek basin reservoirs of East Park, Stony Gorge, and Black Butte had storage ranging from 72 percent to 51 percent of normal.

Orland Unit Water Users' Association began its irrigation season on March 25, 1990. At that time, the forecasted water supply was approximately 75 percent, with no projected carryover storage. These conditions prompted meetings between Reclamation and the association to discuss conservation measures. The association announced a 3 acre-foot per-acre base supply with no additional water available, and Reclamation began crediting the association for operational wastewater diverted into the Tehama-Colusa Canal (rather than releasing it to Stony Creek). The California Department of Fish and Game allowed Reclamation to reduce Black Butte minimum releases to Stony Gorge Creek from 30 ft^3/s to 10 ft^3/s, thus saving an additional 7,260 acre-feet in Black Butte Reservoir.

An unusual storm from May 20 to May 29 produced an average of 2 inches of precipitation in the Stony Creek watershed. Between May 29 and June 14, the three reservoirs gained a total of 13,212 acre-feet as a result of increased runoff and deferred irrigation. With current management practices, the association expects a full water supply in 1991 under high, normal, and low precipitation forecasts.

Ventura Project, California

A stage 1 water emergency was declared in May at the Ventura Project reservoir (Lake Casitas), which supplements ground water supplies for the Casitas Municipal Water District. The emergency was declared when the safe yield of the reservoir was reached; local ground-water supplies have been significantly drawn down during the recent drought. Use was reduced 28 percent between May and September 1990; overall use must be reduced 20 percent for the May 1990-April 1991 period, or a stage 2 emergency will be declared.

Solano Project, California

The Solano Project reservoir, Lake Berryessa, serves the Solano Irrigation District. Surface water supplies have been reduced by the recent drought, but the situation is not critical, and supplemental ground water is available from district wells. However, the district has instituted an agricultural water allocation program in response to the drought; water users' allotments have been reduced about 2 percent from normal levels. However, the drought has caused the water table in the district to drop, and the district shut down some of its wells to prevent damage to the pumps. Other water conservation efforts include installation of a meter network on all check gauges of the Putah South Canal to locate and measure water loss.

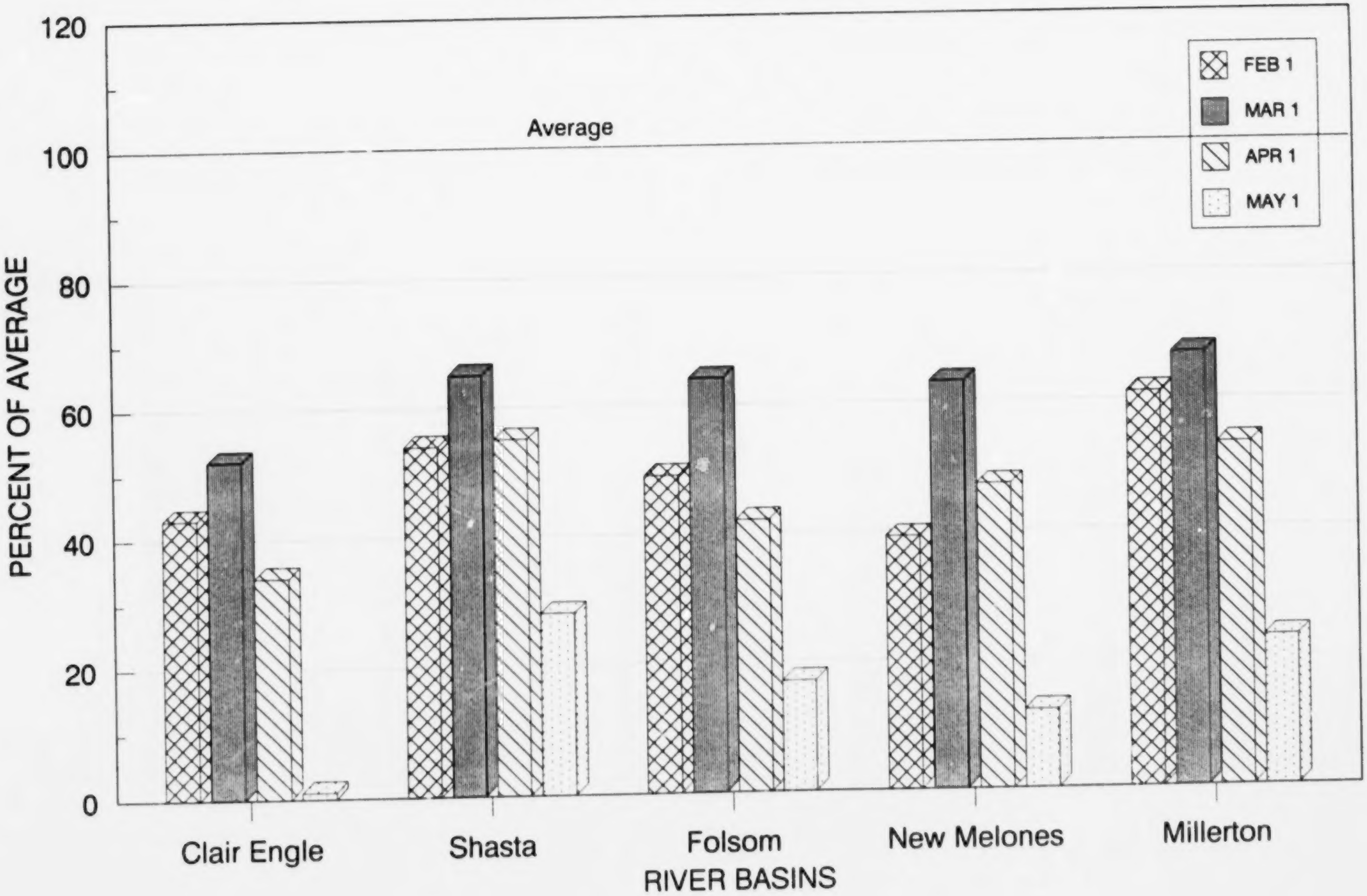
Cachuma Project, California

Lake Cachuma, the primary storage facility for the Cachuma Project, has reached its lowest levels since Bradbury Dam was constructed and the lake was filled in 1953. The lake is now at about one-sixth of its storage capacity. A floating pumping plant was installed in September to lift water to the inlet of the Tecoloate Tunnel, the main conveyance pipeline to the South Coast area. Earlier this year, a siphon was used to draw water from the lake to the tunnel, but the lake level has dropped below the siphon intake.

As a result of severe shortages, water allotments have been reduced to 55 percent of normal for the current water year (ending May 15, 1991). If sufficient rainfall does not occur to replenish storage, allotments will be reduced to 45 percent of normal for the next water year.

Water Year 1990 Snow Water Equivalent

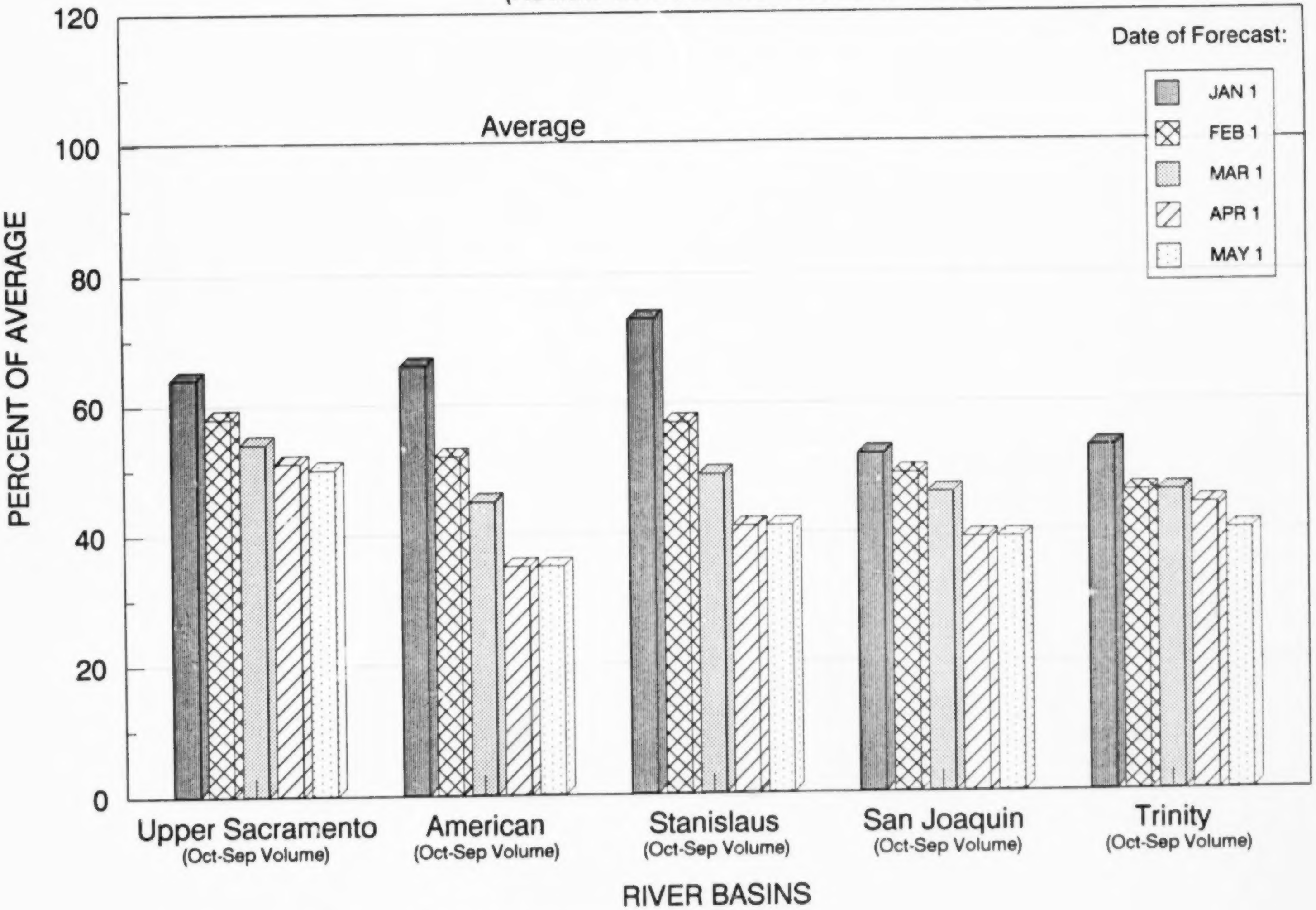
Trends for Mid Pacfic Region



Mid-Pacific Region

Water Year 1990 Streamflow Forecasts[1]

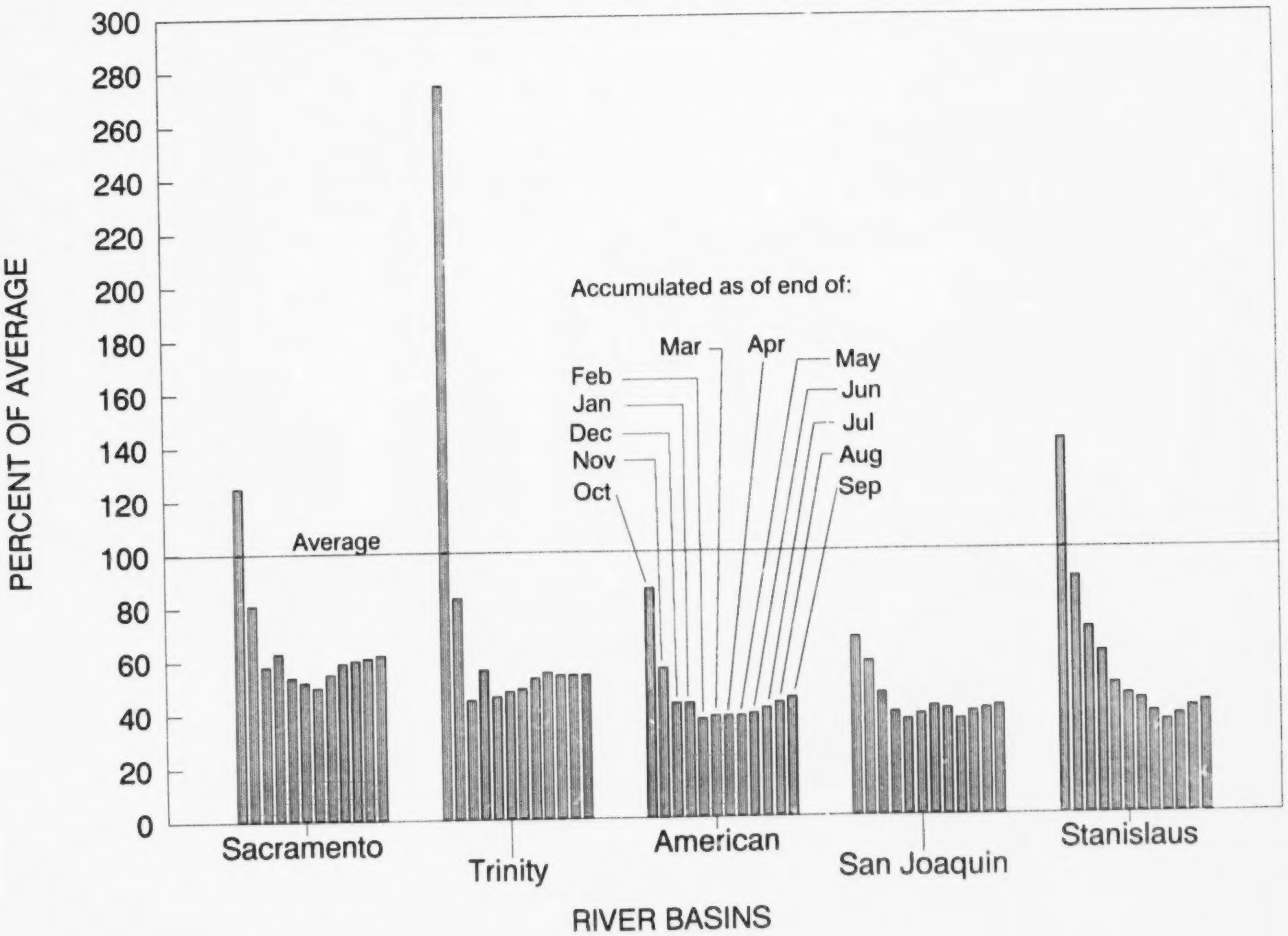
(Review Of What The Forecasts Were)



Note: 1. Data Source: "Water Supply Outlook For The Western U.S." By The Soil Conservation Service and National Weather Service

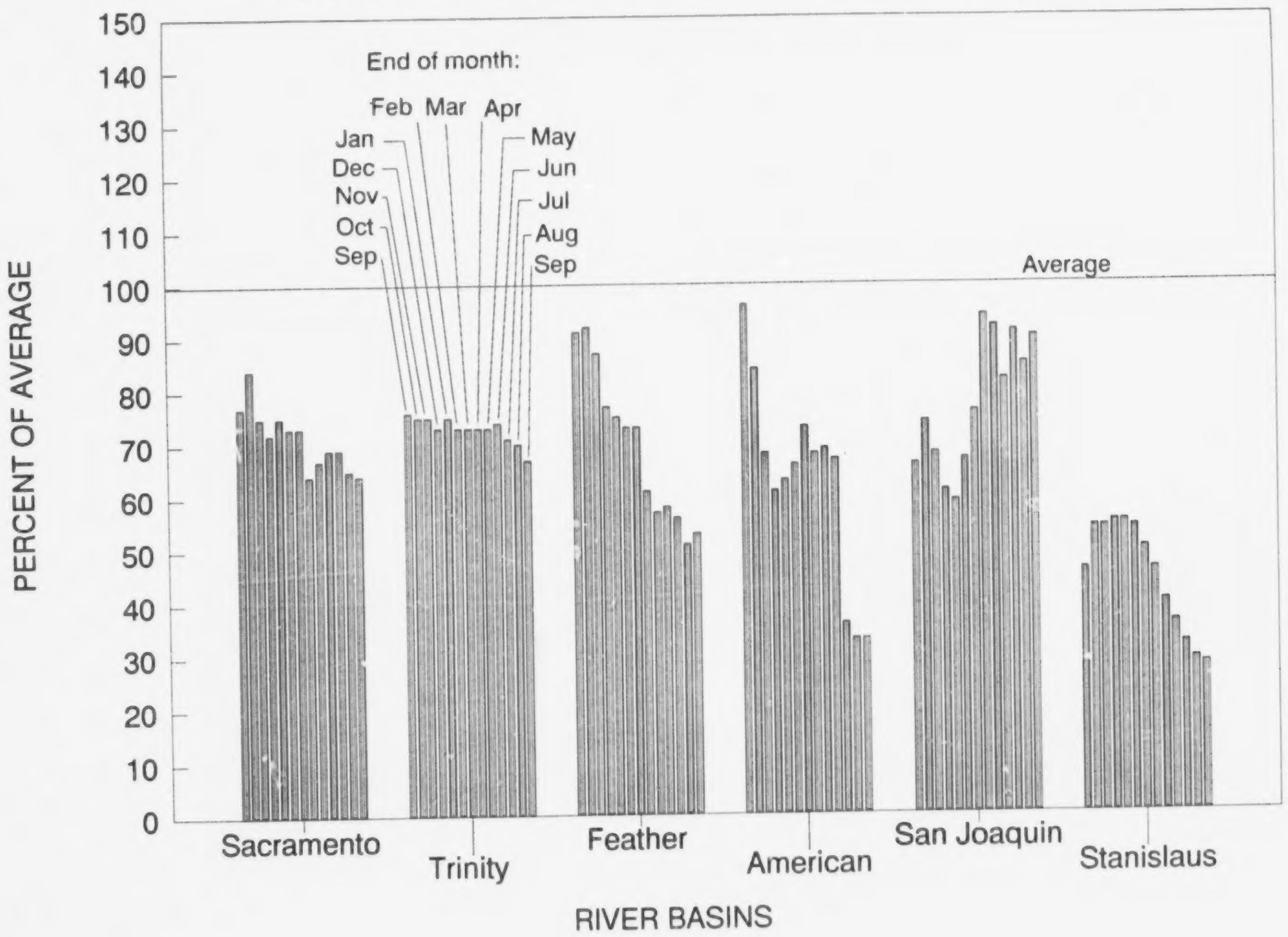
Water Year 1990 Accumulated Inflows, Mid Pacific Region

Percent of Average, October 1, 1989 to September 30, 1990



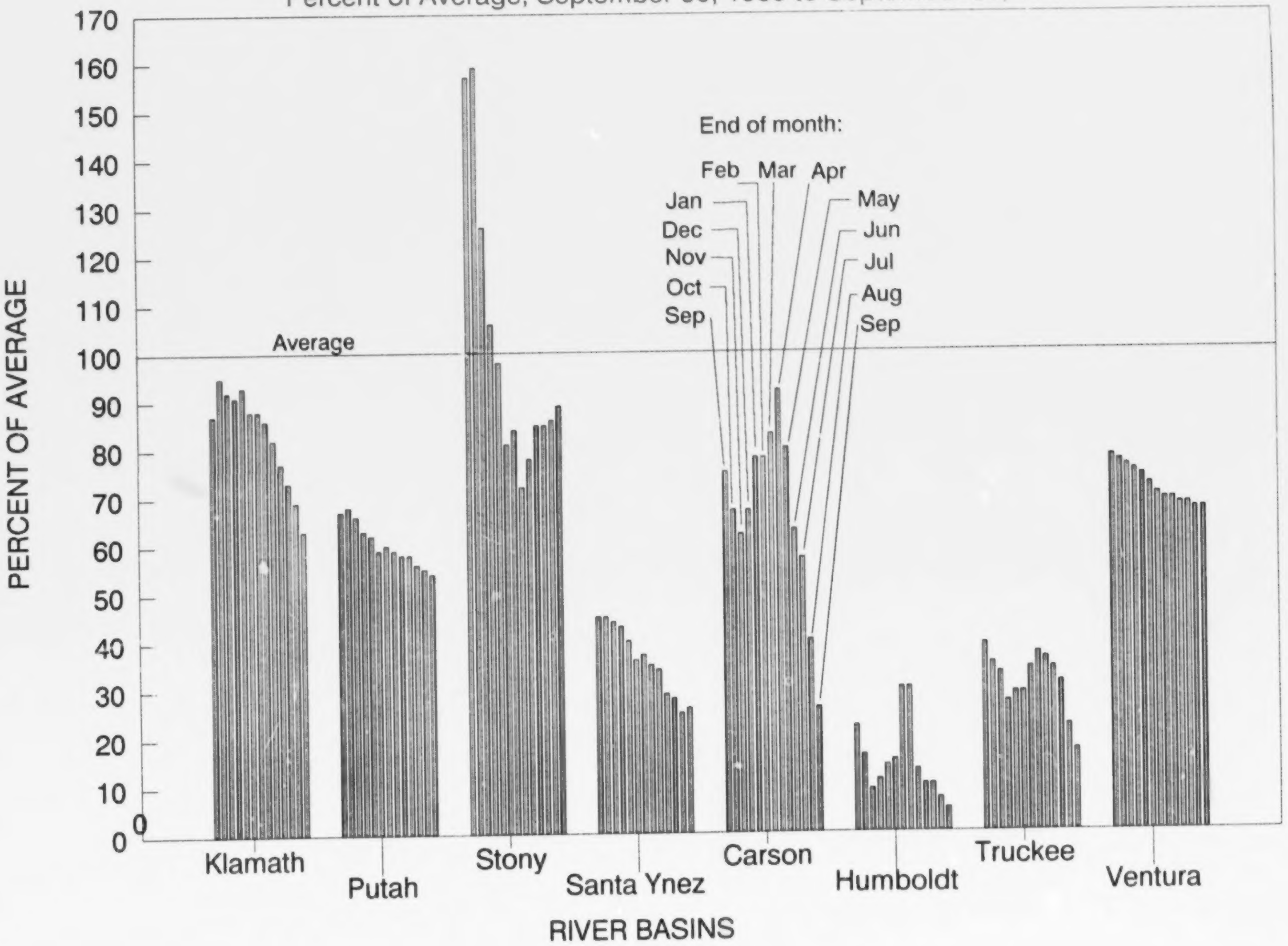
Water Year 1990 Reservoir Storage, Mid-Pacific Region

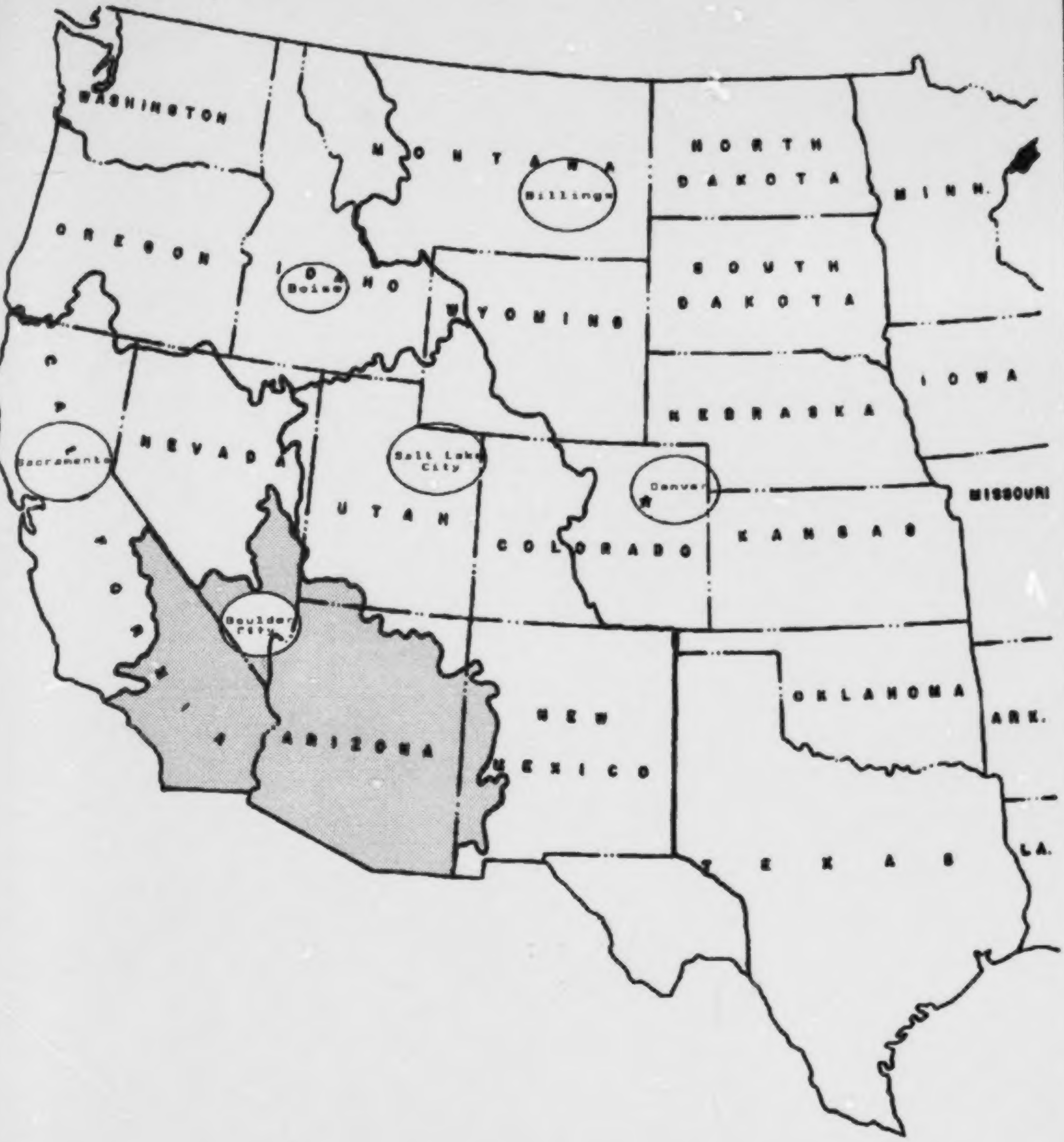
Percent of Average, September 30, 1989 to September 30, 1990



Water Year 1990 Reservoir Storage, Mid-Pacific Region

Percent of Average, September 30, 1989 to September 30, 1990




WASHINGTON
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Billings
OREGON
IDAHO
Boise
SOUTH DAKOTA
WYOMING
IOWA
NEBRASKA
CALIFORNIA
NEVADA
Sacramento
Salt Lake City
Denver
MISSOURI
UTAH
COLORADO
KANSAS
Boulder City
OKLAHOMA
ARK.
ARIZONA
NEW MEXICO
TEXAS
LA.

LOWER COLORADO REGION

EDWARD M. HALLENBECK, REGIONAL DIRECTOR
P.O. BOX 427
BOULDER CITY, NEVADA 89005

LOWER COLORADO REGION

This chapter summarizes water year 1990 water supply conditions, Reclamation's response to drought conditions, and projected water supply conditions for water year 1991 in the Lower Colorado Region. The region includes most of Arizona and portions of California, Nevada, Utah, and New Mexico and encompasses the portion of the Colorado River drainage basin below Lee Ferry, Arizona (near Page, Arizona).

Lower Colorado River Basin

Water Year 1990 Water Supply Conditions

Low runoff in 1988, 1989, and 1990 caused drawdown in all Colorado River system reservoirs. Following a last flood control release in February 1988, only the minimum water deliveries out of storage facilities were maintained to meet obligations pursuant to "The Law of the River." Consequently, the October 1, 1990, system vacant space was approximately 44 million acre-feet.

During water year 1990, soil moisture measurements throughout the basin were at levels associated with extreme drought conditions. This moisture deficiency was never made up during the water year, thus the low runoff conditions of 1990.

Lake Powell.—Glen Canyon Dam was operated to meet the minimum objective release of 8.23 million acre-feet for water year 1990 as set forth in the operating criteria. The below average inflows of 1988, 1989, and 1990 have reduced the storage in the lake by about 7 million acre-feet. The lake, currently about 62 feet from full (about 65 percent of capacity), is projected to continue to drop through the fall and winter, reaching its seasonal low point in March 1991, about 76 feet from full.

During water year 1990, a release of 8.23 million acre-feet was released while preserving the reservoir storage at Lake Powell. For water year 1991, 8.23 million acre-feet again will be released from Lake Powell. Under the most probable conditions in 1991, the lake will not accumulate more storage than in 1990, partly because upper basin reservoirs will be refilled and because of existing dry conditions.

Lake Mead.—Lake Mead storage is reported on a calendar year rather than a water year basis. Lake Mead releases during calendar year 1990 will be approximately 9.1 million acre-feet; during calendar year 1991, releases are projected to be 8.8 million acre-feet, which will satisfy mainstream beneficial consumptive use requests in the lower basin, treaty requirements with Mexico, conveyance losses, and river regulation needs. The outlook for lowest and highest monthly releases for 1991 are about 520,000 acre-feet and 960,000 acre-feet respectively.

With the minimum objective release of 8.23 million acre-feet from Glen Canyon Dam in 1990, Lake Mead rose approximately 2.4 feet to elevation 1191.7 feet through February 1990 and declined to a seasonal low level of 1178.8 feet in August 1990. For the calendar year 1991, Lake Mead will rise approximately 2.2 feet through February 1991 and decline to a seasonal low level of about 1173.0 feet from June through August 1991.

Lakes Mohave and Havasu.—Lakes Mohave and Havasu are scheduled to be drawn down in the winter months to provide storage space for local storm runoff. The reservoirs will be filled in the spring to meet higher summer water needs. This drawdown will also correspond with scheduled September-December maintenance at both Davis and Parker powerplants. The normal filling pattern of these two reservoirs coincides well with the fishery spawning period. Since lake elevations will be similar to previous years, normal conditions are expected for boating and other recreational uses.

Mexican Water Treaty Delivery.—The guaranteed annual delivery of 1.5 million acre-feet of water will be delivered to Mexico during calendar years 1990 and 1991 in accordance with Article 15 of the 1944 Water Treaty and Minute No. 242 of the International Water and Boundary Commission.

Reclamation's Response to Drought Conditions

The 1990 annual operating plan for the Colorado River recognized the below normal inflow and the storage available, as well as the need for water by the lower basin States of Arizona, Nevada, and California. In 1990, therefore, all requests for Colorado River diversions for beneficial water were to be satisfied, as long as total annual consumptive use did not exceed the States' 7.5 million acre-foot apportionment.

During 1990, Reclamation began monitoring consumptive use and projecting total use through the end of the calendar year to help ensure that the lower basin States' apportionment was applied to beneficial use and that diversions did not exceed entitlements. The procedures also helped determine the amount of Arizona's and Nevada's unused apportionment which would be available to California, specifically The Metropolitan Water District of Southern California (MWD).

In 1989, MWD was allowed to use Arizona's and Nevada's unused apportionment. However, use in Arizona and Nevada increased in 1990 (primarily because the

Central Arizona Project [CAP] is nearing completion), and the amount of unused apportionment available to California and MWD was projected to be reduced. However, late summer precipitation in Arizona reduced CAP diversions, allowing MWD to increase its use of Arizona's unused apportionment.

California irrigation districts were told in February that if their use exceeded their 3.85 million acre-feet apportionment, revised diversion schedules would be requested. Moreover, the users were told that if the revised schedules did not limit use, delivery schedule reductions would be required.

As the irrigation season progressed, Reclamation developed a public affairs program to inform water users about current water supply conditions and water management and conservation activities. In May, Reclamation provided a water conservation fact sheet to agricultural water users. In June, Reclamation held a "Law of the River" seminar for all Colorado River contractors. Reclamation also prepared and distributed the first of a planned series of newsletters on water supply conditions and management. In addition, a Colorado River media visitation program and slide show were prepared to educate water users on ways to improve water management and conservation.

Reclamation met with Indian communities and irrigation district managers and boards of directors to discuss Reclamation activities and to solicit the water users' cooperation.

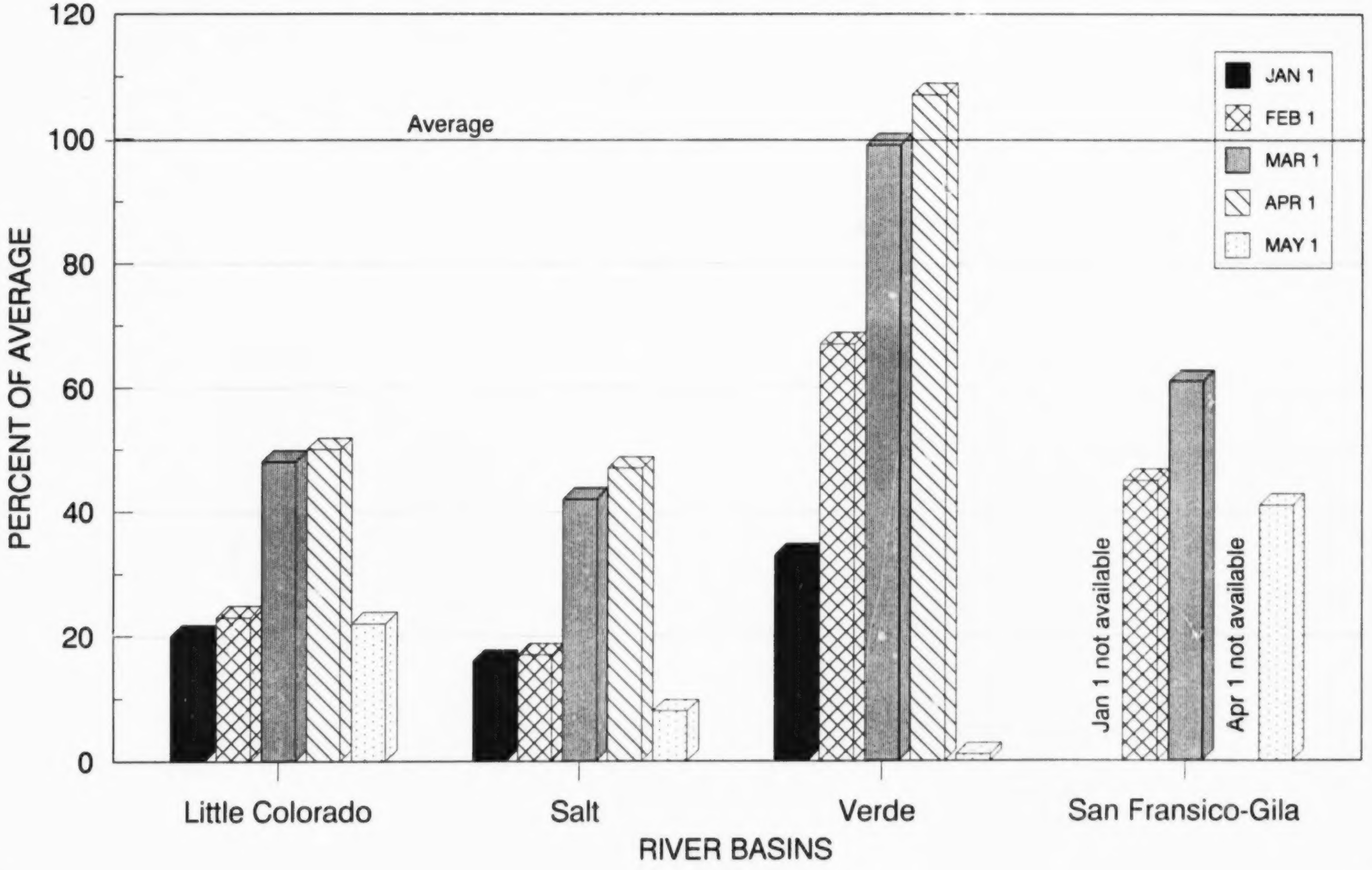
Reclamation, along with several Federal and State agencies, is creating a pilot Management Improvement Program to help irrigation districts improve water and energy management and use. The irrigation districts will share the cost of developing, demonstrating, and evaluating the program.

Reclamation reached an interim water service agreement with the Central Arizona Conservation District and the San Carlos Irrigation Project (SCIP). Under the agreement, water from the Central Arizona Project will be delivered through the Pima Lateral Feeder Canal to the SCIP in lieu of diversions from San Carlos Lake. The deliveries will allow enough water to remain in San Carlos Lake to prevent fish kills caused by low water levels.

Reclamation is facilitating an agreement between the Salt River Project (SRP) and the city of Tempe, Arizona. Under the agreement, CAP water will be delivered to Tempe in lieu of SRP ground water so that the SRP can retain ground water in storage.

Water Year 1990 Snow Water Equivalent

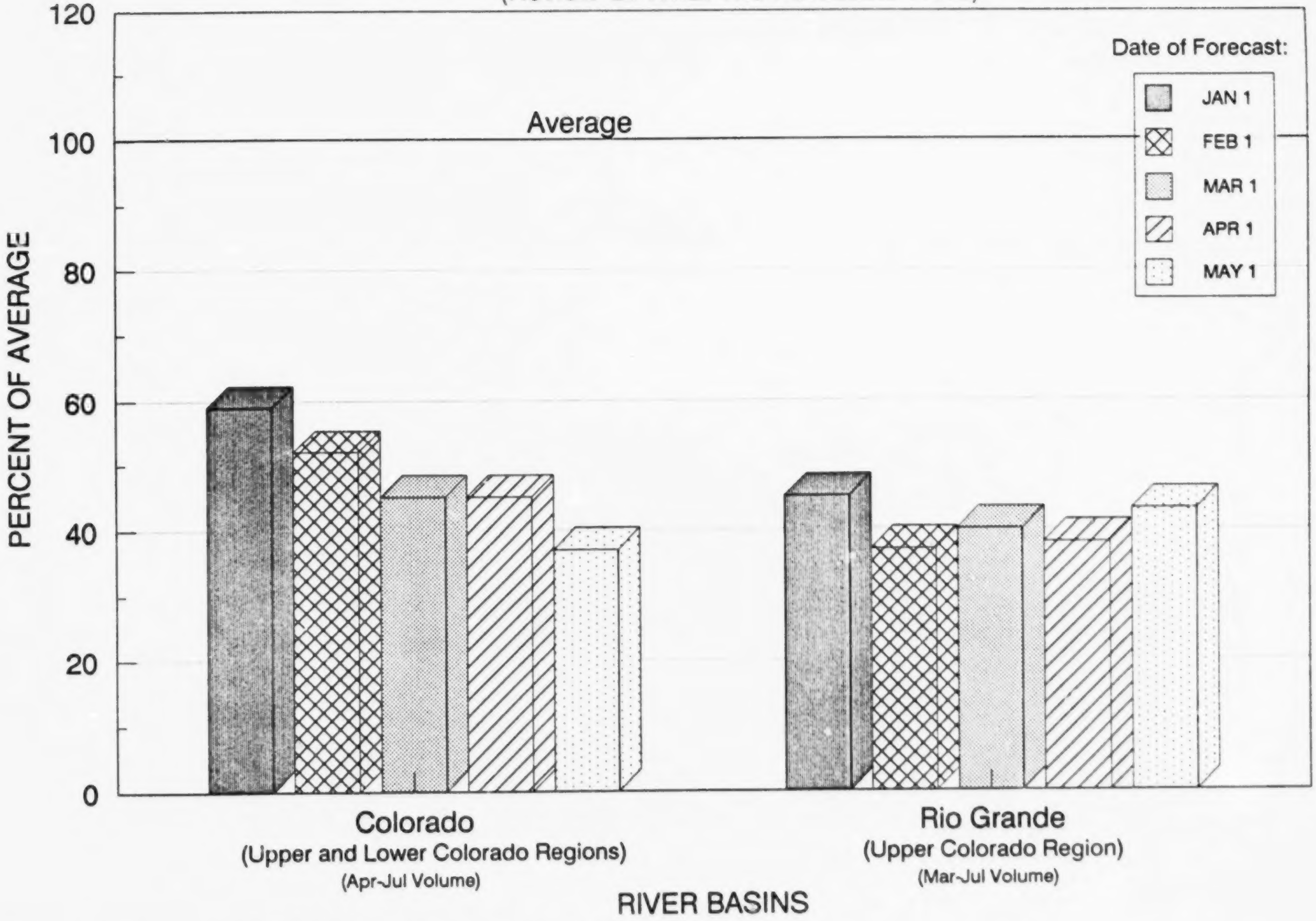
Trends for Lower Colorado Region



Upper and Lower Colorado Regions

Water Year 1990 Streamflow Forecasts[1]

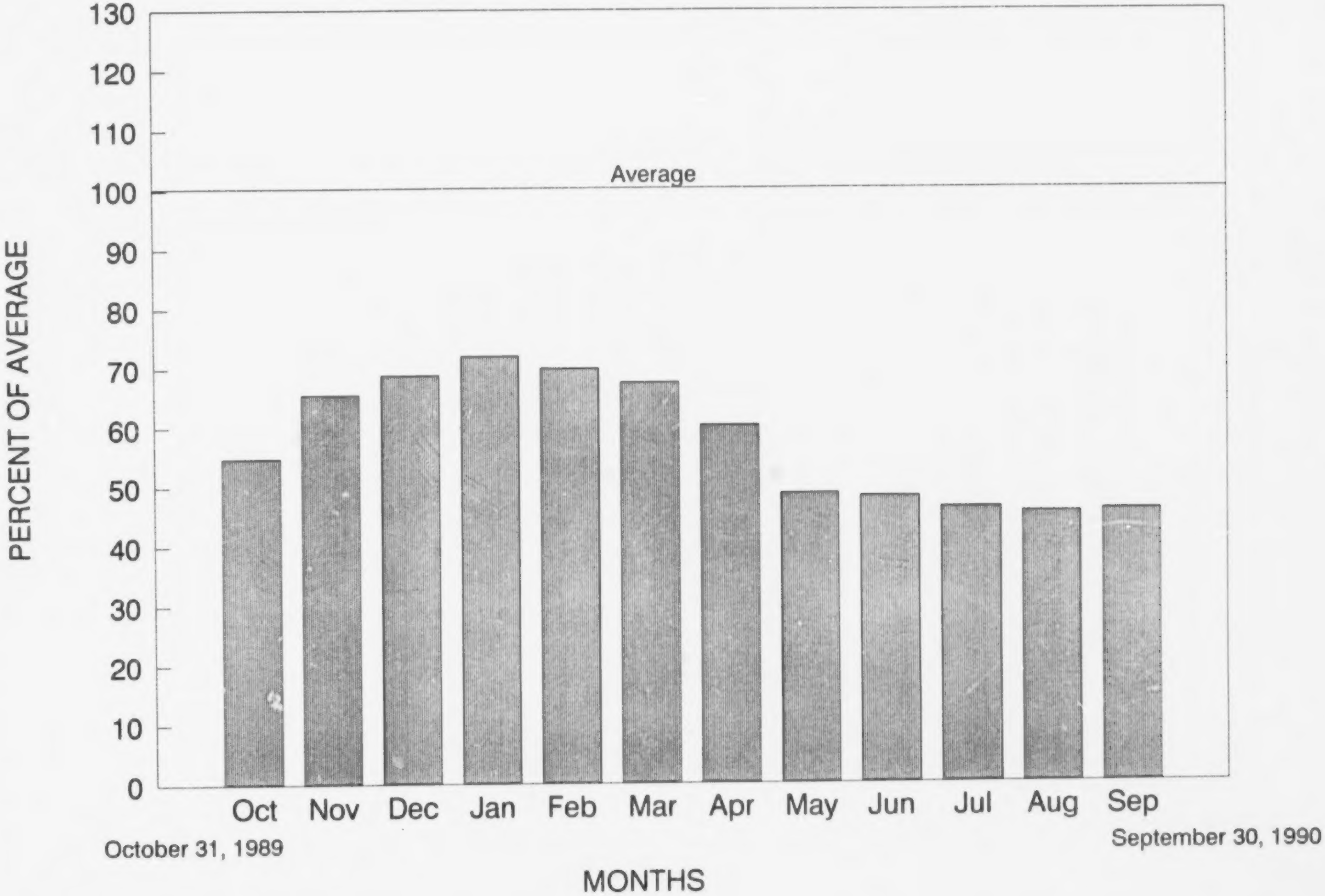
(Review Of What The Forecasts Were)



Note: 1. Data Source: "Water Supply Outlook For The Western U.S." By The Soil Conservation Service and National Weather Service

Water Year 1990 Accumulated Inflows, Lower Colorado Region

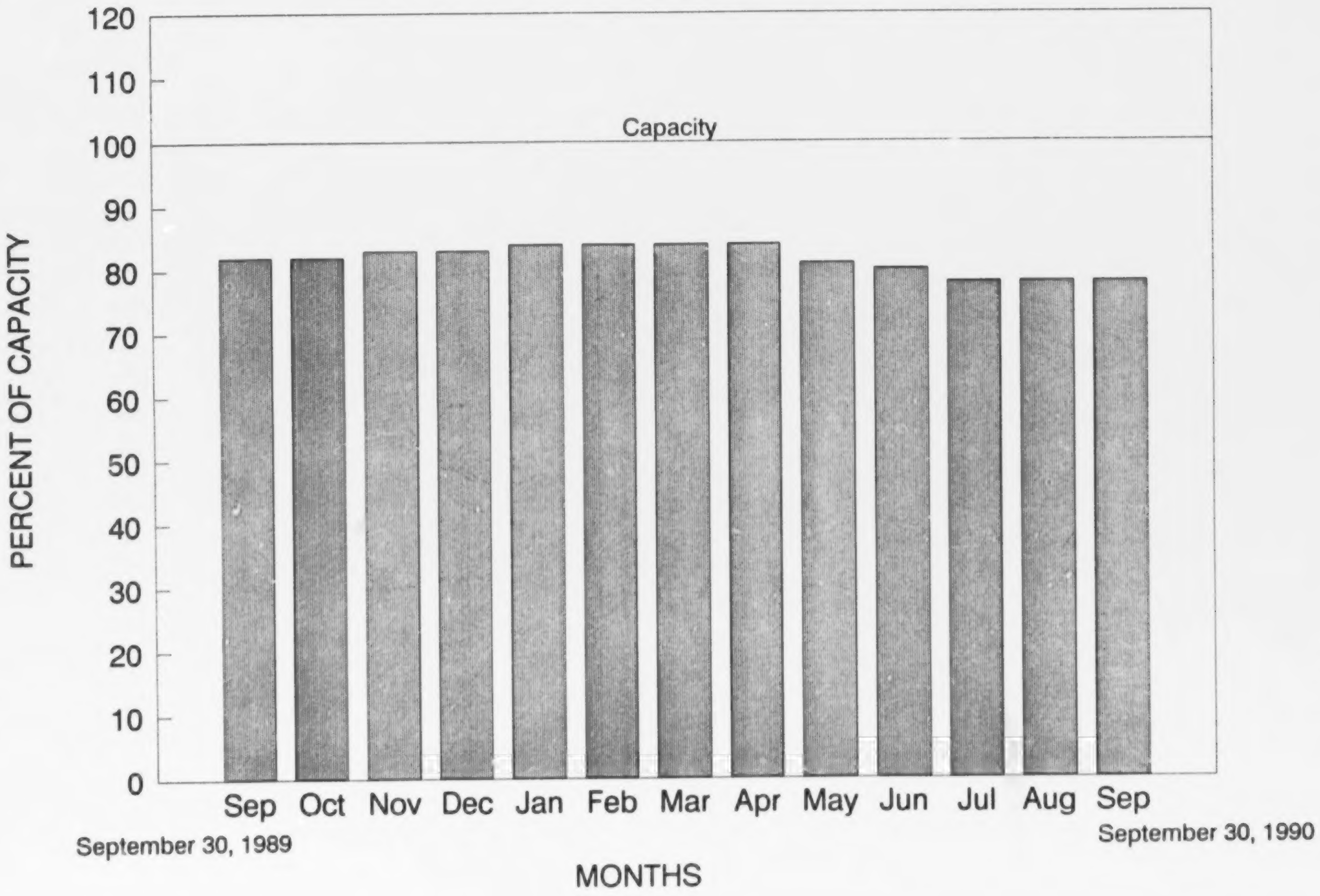
Percent of Average, Lake Powell



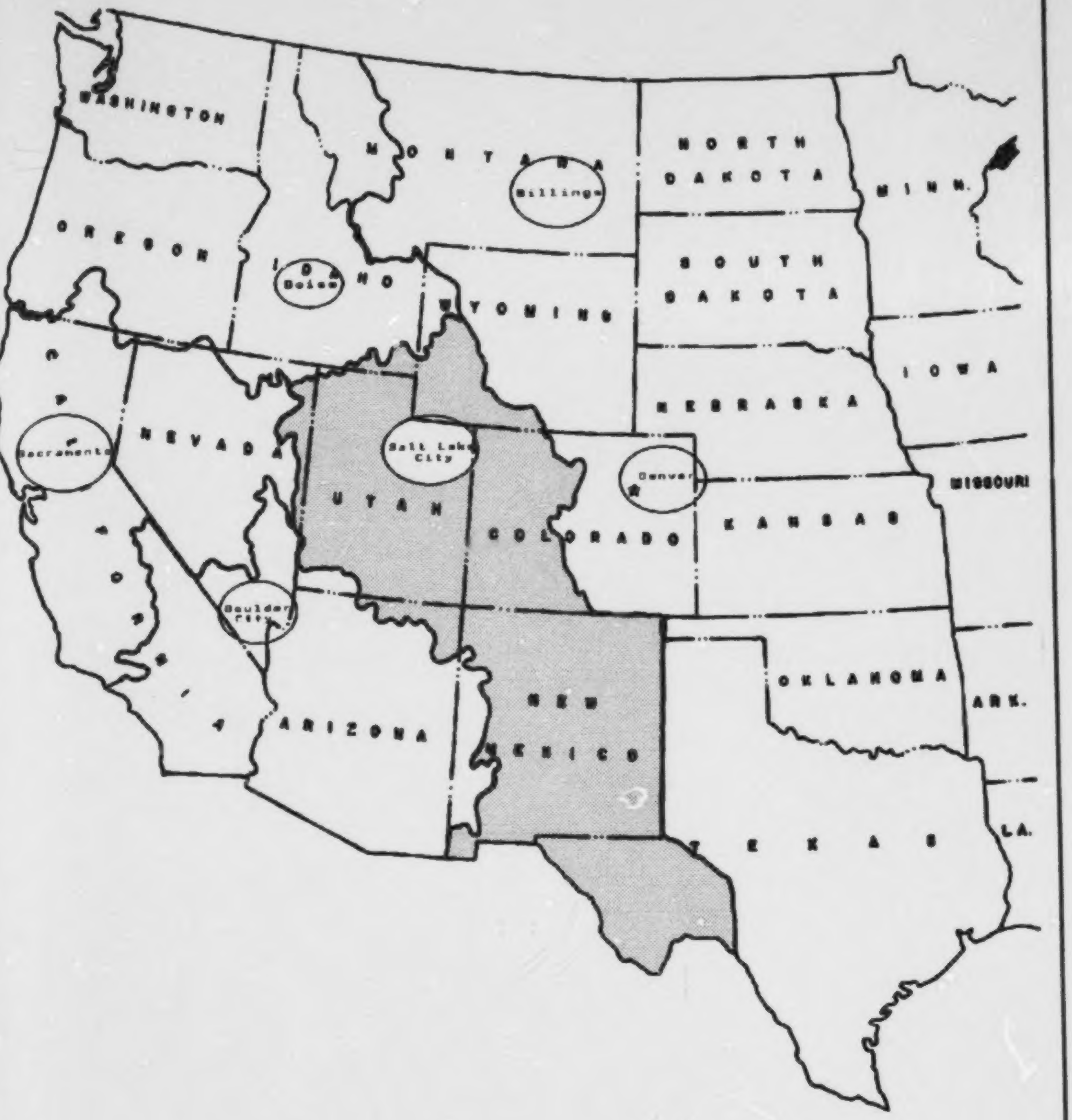
Note: The water year runs from October 1 through September 30

Water Year[2] 1990 Reservoir Storage, Lower Colorado Region

Percent of Capacity[1], Colorado River Basin



Notes: 1. Lower Colorado Region reports storage as a percent of capacity 2. The water year runs from October 1 through September 30.


WASHINGTON
MONTANA
Billings
NORTH DAKOTA
MINN.
OREGON
IDAHO
Boise
WYOMING
SOUTH DAKOTA
IOWA
CALIFORNIA
NEBRASKA
NEVADA
Sacramento
Salt Lake City
Denver
MISSOURI
UTAH
COLORADO
KANSAS
Boulder City
OKLAHOMA
ARK.
NEW MEXICO
ARIZONA
TEXAS
LA.

UPPER COLORADO REGION

ROLAND ROBISON, REGIONAL DIRECTOR
P.O. BOX 11568
SALT LAKE CITY, UTAH 84147

UPPER COLORADO REGION

This chapter summarizes water year 1990 water supply conditions, projected water year 1991 operations, and Reclamation's response to drought in the Upper Colorado Region. The region includes most of Utah and New Mexico and portions of Nevada, Idaho, Wyoming, Colorado, and Texas. It encompasses the Colorado River drainage above Lees Ferry, Arizona, the Rio Grande basin, and the closed-basin drainages flowing westward from the Wasatch Range in Utah.

Colorado River Basin

Water Year 1990 Water Supply Conditions

The runoff into Lake Powell during water year 1988 was approximately 70 percent of normal, in water year 1989 approximately 53 percent of normal, and approximately 46 percent of normal in water year 1990.

The low runoff years of 1988, 1989, and 1990 have caused a drawdown in all Colorado River system reservoirs. The vacant space on October 1, 1990, in the mainstem reservoirs was about 16.7 million acre-feet. The vacant space is a result of the three successive years of low inflow while maintaining the minimum deliveries of water out of storage facilities to meet obligations pursuant to "The Law of the River."

Current soil moisture measurements throughout the basin are at levels associated with moderate to extreme drought conditions. This moisture deficiency must be satisfied by precipitation before runoff can occur, thus increasing the probability of below average runoff during water year 1991.

In addition to complying with the basic requirements of the operating criteria, several specific operating issues were addressed in preparing the annual operating plan for water year 1991. Special consideration was given to the dry condition of and vacant reservoir space that currently exist. The specific operating issues addressed are:

- fully meeting the calendar year 1991 reasonable beneficial Colorado River mainstream consumptive water uses in the lower basin, not to exceed 7.5 million acre-feet, as provided by the operating criteria,

- delivering firm power in accordance with energy contracts,

- providing minimum and specific releases for fish and wildlife and recreational purposes,

- refilling vacant system reservoir storage space,

- providing potential for flood control releases before shortages may occur,
- releasing water to the Gulf of California,
- complying with the 1944 Mexican Water Treaty and Minute No. 242 of the International Boundary Water Commission,
- recognizing the lack of fully developed water use in the upper basin and in Arizona and Nevada of the lower basin,
- storing unused water apportionments in 1991,
- recognizing guidelines for reservoir filling and drawdown recommended for fish spawning periods in Lake Mead,
- complying fully with compact, decree, statutory, and water delivery obligations, and
- evaluating other short- and long-term effects of 1991 water use decisions.

Water Supply Assumptions.—For 1991 operations, three reservoir inflow scenarios were developed and analyzed; statistically, these are approximately the upper quartile, lower quartile, and lower decile inflows and have been respectively labeled the probable maximum, most probable, and probable minimum.

The water year 1991 unregulated inflow above Lake Powell for the three water-supply scenarios was 14,7, 8.7, and 5.4 million acre-feet, respectively. The resulting inflow volumes were used as input for Reclamation's monthly reservoir operation planning computer model, which is used to plan reservoir operations for the upcoming 12-month period. With assumed water year 1991 inflow and reservoir storage conditions, projected monthly releases were adjusted until release and storage levels achieved project purposes and priorities. According to the studies, no project shortages would occur under any inflow scenario.

Additional Analysis.—Special long-range studies were conducted to test the the risk of future shortages if California is allowed to use water apportioned to but unused by Arizona and Nevada (not to exceed 7.5 million acre-feet of total mainstream use in the lower basin during calendar year 1991). The studies used very conservative assumptions about future water supplies; 10 of 15 water supply alternatives assumed less than average reservoir inflow. These very conservative assumptions were used because of the declining reservoir storage during 1989 and 1990 and to maximize the risk of future shortages. These studies projected 50 years into the future to test the risks of shortages and evaluated several specific parameters. These studies indicate that for the next 5 years there are: (1) no increase in the risk of shortages; (2) reduced risk of flood control releases; and (3) reduced excess deliveries to Mexico.

Reservoir Operations—General.—At appropriate locations in the upper and lower basins, minimum instream flow levels have been established which preserve the present aquatic resources downstream of certain Colorado River dams. In many cases, these resources were poor or nonexistent prior to dam construction, and the subsequent minimum, cool water releases have provided an improved environment for aquatic resources and sport fisheries. In general, controlled releases create an extended recreation season and reduce the high flow periods in May and June. A return to average runoff levels in the future will benefit fish, wildlife and recreation uses and other project purposes.

The following sections discuss the 1990 operations of each Colorado River Storage Project reservoir during 1990 and the projected 1991 operations with respect to compact, decree, statutory, and water delivery obligations, as well as instream flow needs for present aquatic ecology, where appropriate.

Fontenelle Reservoir Operations.—Water year 1990 was the first full year of normal operations in more than 5 years because of dam safety concerns. Fontenelle was the only Colorado River Storage Project reservoir that filled this year and, because of the below normal runoff, only about 2,000 acre-feet of water bypassed the turbines. Since the mean annual inflow of 1.2 million acre-feet far exceeds the storage capacity of 345,000 acre-feet, there is little chance that the reservoir will not fill during water year 1991. To minimize the high releases that occur in the spring and to ensure that the reservoir fills, it will be drawn down to an appropriate level this winter, probably to minimum pool elevation (6463 feet), which corresponds to a volume of 93,000 acre-feet of live storage.

Releases are projected to remain constant this fall and winter because the Wyoming Game and Fish Department is testing the effectiveness of artificial spawning beds for kokanee (landlocked) salmon. Releases should average about 900 ft^3/s through the fall and winter, depending upon fall rainstorms. At this level, releases should provide an appropriate drawdown for next year's runoff season as well as provide greater benefits to the fishery and improve water quality for downstream municipal and industrial uses. Under all but the most adverse inflow assumption, the reservoir is expected to fill in the spring of 1991.

Flaming Gorge Reservoir Operations.—As a result of several extremely dry years in the Green River basin, Flaming Gorge Reservoir has been drawn down about 20 feet from full. Releases during most of 1990 were restricted to minimum flows of 800 ft^3/s, which are projected to continue through much of water year 1991. A limited number of specific releases were provided in 1990 for studies about endangered fish survival requirements. Colorado squawfish young-of-the-year were found in the mainstem of the Green River in early July 1990, and releases from Flaming Gorge Reservoir were restricted to provide better habitat for the young Colorado squawfish.

These same release restrictions will be implemented during water year 1991. The release restrictions recommended by the U.S. Fish and Wildlife Service are as follows:

- Total monthly releases should not exceed 100,000 acre-feet,
- Maximum releases of 2,600 ft^3/s except that up to 4,000 ft^3/s can be released for up to 2 hours per day.
- Minimum releases of 800 ft^3/s.

With this operating plan and the most probable inflow assumption, the reservoir will refill in spring 1992.

Blue Mesa, Morrow Point, and Crystal Reservoir Operations.—The Gunnison River basin has also experienced below average runoff, substantially reducing reservoir storage. In 1988, the reservoir was 40 feet from full, and in 1989, the reservoir had recovered to within 16 feet of full. In 1990, the reservoir declined to 25 feet from full, even though releases from Crystal Reservoir were limited to meet the delivery requirements of the Uncompahgre Valley Project and to provide a minimum flow of 300 ft^3/s in the Gunnison River of the Gunnison National Monument. These minimal releases are projected to continue until spring 1991, when, under most probable inflow conditions, Blue Mesa Reservoir will refill and the downstream releases will increase. To protect the blue ribbon trout fishery in the Black Canyon, releases are carefully planned to minimize large monthly changes in flow below the Gunnison Tunnel Diversion. The forecasted runoff during spring 1991 will be constantly monitored to achieve this objective.

Navajo Reservoir Operations.—Like other upper Colorado River reservoirs, Navajo Reservoir also experienced well below normal runoff in water year 1990, leaving the reservoir about 316,000 acre-feet short of full. Releases to the San Juan River were reduced to 500 ft^3/s during much of the 1990 water year and will only be increased in order to satisfy downstream water rights. This release pattern is expected to continue through water year 1991. With normal runoff, the reservoir should refill in 1992.

Lake Powell Operations.—To maintain a minimum release of 8.23 million acre-feet annually from Lake Powell as specified in the operating criteria, the below average inflow in 1988, 1989, and 1990 has reduced the storage in the reservoir by about 9 million acre-feet. Currently about 52 feet from full (about 74 percent of capacity), the lake is projected to continue to drop through the fall and winter, reaching its seasonal low point in March 1991, about 75 feet from full.

During water year 1991, 8.23 million acre-feet again will be released in an effort to preserve the reservoir storage at Lake Powell. Under most probable conditions, the lake will not accumulate as much storage in 1991 as in 1990 because of the refilling of upstream reservoirs. It will take several years of average inflow to refill Lake Powell.

Following the extreme flood runoff years of 1983 through 1986, the Glen Canyon environmental studies and reports concluded that releases greater than powerplant capacity were harmful to the ecology of the Grand Canyon and recommended limiting the frequency of these flood releases. Based on these recommendations and similar concerns from power customers regarding powerplant bypasses, an operating strategy was developed within the constraints of the existing operating criteria for Glen Canyon Dam that reduced the probability of releases greater than powerplant capacity. The frequency of these releases was reduced from approximately once every 4 years to approximately once every 20 years. In addition to reducing environmental damage, this also has decreased spillway maintenance and repair costs and increased total power generation.

The two primary factors which produced these effects were: (1) reducing by 500,000 acre-feet the July target storage content of Lake Powell, and (2) reacting more quickly to changes in the forecasted runoff as the runoff season progresses. Each of these factors contribute to late-spring flexibility in accommodating large increases in the spring runoff such as occurred in 1983, 1985, and 1986.

Because the level of Lake Powell has dropped considerably, the risk of releases greater than powerplant capacity during water year 1991 is negligible.

Reclamation's Response to Drought Conditions

At the beginning of the 1990 irrigation season, Reclamation determined that all releases from all mainstem upper Colorado facilities would be restricted to minimum flows for the entire year. As stated before, releases from Glen Canyon Dam were restricted to the 8.23 million acre-feet the minimum objective specified in the operating criteria.

Although the 1990 annual release from Lake Powell was restricted to 8.23 million acre-feet, Reclamation negotiated with the Colorado River Basin States to provide research flows to support studies associated with the Glen Canyon Dam environmental impact statement. These research flows are expected to significantly affect power production and revenues, but through coordination with researchers and the States, the flows did not affect the upper basin releases specified in the operating criteria.

In the Green, Colorado, and Great basins, streamflows ranged from 35 to 65 percent of average. However, because of adequate reservoir storage and aggressive water conservation by water users, water supply shortages were limited to very small Reclamation projects and to areas relying solely on streamflows. On the mainstems of the Colorado and Green Rivers, reservoirs were limited to minimum releases to conserve storage.

In the San Juan River basin, ongoing drought conditions prompted water conservation measures to extend existing supplies. Water users agreed to end irrigating earlier in the fall, to begin irrigating later in the spring, and to closely administer water supplies. These actions, combined with timely summer rains, resulted in normal water supplies and carryover storage in the reservoirs.

In the Colorado and Gunnison River basins, where streamflows ranged from 40 to 70 percent of normal, several smaller projects suffered shortages. In the mainstems of the Gunnison and Colorado Rivers, streamflows and storage were sufficient to prevent any consumptive use shortages and to meet minimum streamflow requirements for fisheries.

Reclamation took the following actions to help mitigate shortages in the Colorado and Gunnison River basins:

> The Lower Molina powerplant (Collbran Project) was shut down for the summer because of insufficient water supplies. Available water supplies were used for irrigation deliveries.
>
> The impacts of allocating water under alternative water supply conditions were studied as part of the joint Reclamation/Geological Survey Global Climate Change Response Program. These studies address a range of solutions, including highest-value water used, modified land-use patterning, and alternative reservoir operation objectives and criteria.
>
> In cooperation with the Dolores Water Conservancy District, Reclamation increased releases below McPhee Dam on the Dolores River from 20 cubic feet per second (ft^3/s) to 50 ft^3/s in June to support the downstream gold medal fishery. Releases were dropped to 30 ft^3/s in September; in early November, they will be raised to 34 ft^3/s, where they will remain for the winter. Fishery biologists monitored temperatures and aquatic conditions in the river; these studies will provide important data for a Federal/State interagency task force that is reevaluating reservoir operating criteria.
>
> An interim 3-year agreement is being negotiated for the release of water for trout below McPhee Reservoir. The agreement will not set a precedent for the release of water after the project is fully developed. During the

term of the agreement, studies and negotiations will be conducted to evaluate downstream release patterns to optimize fish and wildlife purposes.

Rio Grande Basin, New Mexico and Texas

Water Year 1990 Water Supply Conditions

Because of an abundance of mid-summer moisture in the Rio Grande valley, reservoir storage use for the 1990 irrigation season within the Rio Grande Project was overestimated by 30,000 to 40,000 acre-feet, based on the March 1, 1990, forecast. Smaller projects generally used the predicted amount of reservoir storage; they now need normal to above normal conditions in 1991 to add water to storage. In general, conditions improved slightly over early forecasts as the season progressed, with runoff flows adding up to 53 percent of normal on the Rio Grande at Otowi. Summer moisture also aided projects on the Pecos River; however, nearly all reservoir storage was used in 1990, as predicted for the developed conditions.

Early predictions for Rio Grande basin streamflow runoff were very low (30-40 percent) throughout the basin. As the season progressed, late spring moisture increased the forecasts slightly, but heavy use of reservoir storage was anticipated. Beginning in early July, summer rains improved conditions in the basin, and irrigation demand for reservoir storage decreased significantly. Good moisture conditions continued through September, resulting in good reservoir storage carryover potential for the 1991 season. Smaller Reclamation projects within the basin need normal to above normal runoff conditions to replenish reservoir storage used in the past 3 years.

Inflow to Elephant Butte Reservoir for 1990 for the March through July forecast period was 165,000 acre-feet, or 34 percent of normal. Inflow for water year 1990 was 351,000 acre-feet, or 40 percent of the long-term average. However, since combined storage at the end of 1989 was 1,706,000 acre-feet or 201 percent of long-term average, a full supply to all water users was available for the year. Elephant Butte Dam releases were projected to be 723,000 acre-feet for the year, and Caballo releases were projected to be 740,000 acre-feet. Actual releases from Elephant Butte Dam were 658,000 acre-feet and 680,000 acre-feet from Caballo Dam. Combined storage of both reservoirs was 1,297,000 acre-feet at the end of water year 1990, or 237,000 acre-feet lower than projected at the beginning of the year for normal conditions.

The January 1, 1990, forecast for the San Marcial gage (upstream from Elephant Butte Reservoir) was 155,000 acre-feet, or 32 percent of normal. Each month thereafter, from February through May, the forecasts were less than 32 percent of normal. The final forecast of June 1, 1990, was 34 percent of normal. The forecast had very little impact on operations for 1990 because of the large amount of carryover storage. Operations were affected most by the request from the irrigation districts to reduce the storage of Caballo Reservoir in order to reduce evaporation. The original October 1989 plan was to have a peak storage in Caballo Reservoir of 103,000 acre-feet by April 1990. After discussions with the districts, it was agreed the maximum storage would be 60,000 acre-feet, and the minimum storage would be 25,000 acre-feet by the end of the irrigation season. It was difficult to control Caballo Reservoir storage at a steady level, and excessive fluctuations in power plant generation occurred because irrigation demand changes cannot be anticipated and lead time is required to make schedule changes to powerplant generation. This problem will continue in 1991 because of the similar operation plan.

Projections for 1991 project operations for each of three water supply scenarios are as follows:

Most Probable (100 percent of normal).—With the most probable runoff, flows at San Marcial gage for March through July would be 485,000 acre-feet or 100 percent of normal. Maximum storage in Elephant Butte Reservoir would reach 1,391,000 acre-feet in February 1991 and drop to 1,189,000 acre-feet in September 1991. Releases from Elephant Butte Dam would be 716,000 acre-feet. Caballo Reservoir maximum storage would occur in May 1991 at 55,000 acre-feet and drop to 25,000 acre-feet in September 1991, with a release of 740,000 acre-feet. A full supply of water would be available to all users.

This scenario would require the Rio Grande (at Otowi) index to be 672,000 acre-feet during the March through July period and 897,000 acre-feet for the 1990-91 water year. This would result in a near full supply for the larger projects requiring supplemental San Juan-Chama releases of 70,000 to 90,000 acre-feet depending on the timing of the runoff. Smaller projects would experience minor shortages.

The Carlsbad Irrigation District will experience moderate shortages within the Pecos River basin under this scenario, as there is little carryover storage as of the beginning of water year 1991.

Reasonable Minimum (25 percent of normal).—With reasonable minimum runoff, flows at San Marcial gage would be 90,000 acre-feet, or 19 percent of normal. Maximum storage in Elephant Butte Reservoir would be 1,320,000 acre-feet in February 1991, and the minimum would be 577,000 acre-feet in October 1991. Releases from Elephant Butte Dam would be 780,000 acre-feet. Caballo Reservoir maximum storage would occur in May at 55,000 acre-feet and drop to 9,000 acre-feet in October 1991, with a release of 790,000 acre-feet. A full supply of water would be available to all users; however, a serious shortage could occur in 1992.

If this scenario occurs, all projects in the Rio Grande basin will experience moderate to severe shortages. Larger projects like the Middle Rio Grande will get through the season with careful management of existing storage. Supplemental San-Juan Chama supplies of about 100,000 acre-feet to 150,000 acre-feet will be necessary to sustain the demand. Otowi flows in the March-July period are estimated at 187,000 acre-feet and 393,000 acre-feet for water year 1991.

Extreme surface flow shortages would develop on the Pecos because carryover storage is now essentially nonexistent; thus farmers would rely heavily on groundwater sources.

Reasonable Maximum (200 percent of Normal).—With reasonable maximum runoff, flows at San Marcial gage would be 1,165,000 acre-feet, or 240 percent of normal. The maximum storage in Elephant Butte Reservoir would be 2,040,000 acre-feet in November, and minimum storage would be 1,522,000 acre-feet at the end of December 1990. Total release from Elephant Butte Dam would be 967,000 acre-feet, including about 88,000 acre-feet to be released in June in excess of the powerplant capacity. Caballo Reservoir would be filled to a capacity of 132,000 acre-feet, assuming a 100-year flood space reservation would be made below the new reservoir restriction of elevation 4164. Total releases from Caballo Dam would be 932,000 acre-feet, including 192,000 acre-feet in excess of irrigation demand. A full supply would be available to all users.

Under this scenario, all projects within the upper Rio Grande basin would have full supplies with the Middle Rio Grande Project requiring 30,000 to 60,000 acre-feet of San Juan-Chama releases in the late season. Flows at Otowi are estimated to be 1,344,000 acre-feet in March through July and 1,662,000 acre-feet for the 1991 water year.

Conditions within the Pecos River basin under this scenario provide a full water supply to Carlsbad Irrigation District with some carryover storage potential.

Reclamation's Response to Drought Conditions

Snowmelt runoff was forecast at 40 percent of average in the Rio Grande and Pecos River basins; Reclamation alerted the irrigation districts and the general public about the potential for drought:

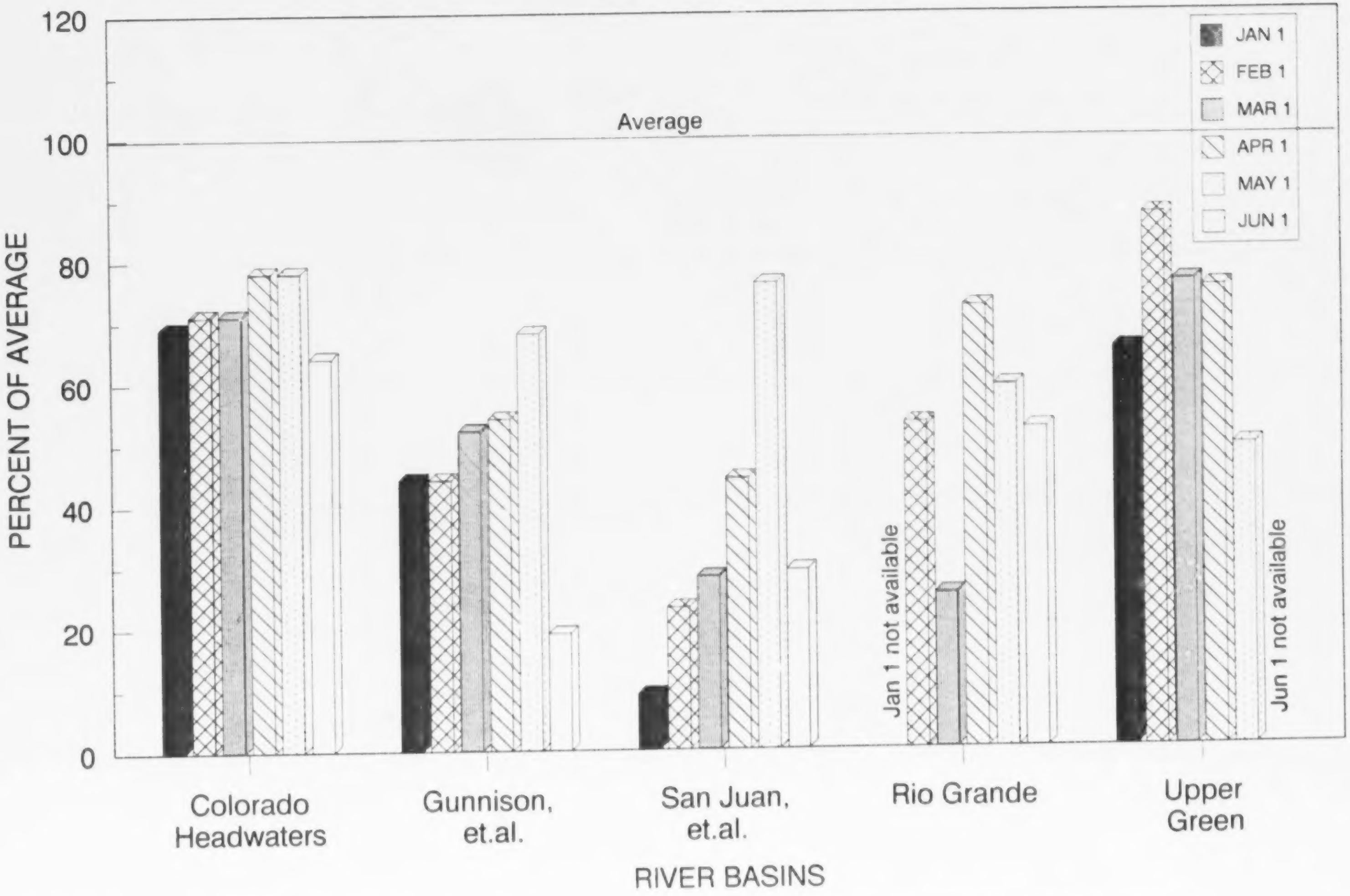
> Approximately 150 copies of the annual operating plan were distributed to various agencies, groups, and concerned citizens.
>
> The annual operating plan was also presented to the public and news media at public meetings. Water supply conditions were discussed, and careful water management was encouraged.

Reclamation personnel regularly discussed runoff conditions with the irrigation districts. Reclamation also assisted at operational planning meetings and advised the districts on technical issues.

Reclamation helped negotiate water transfers from municipalities with surplus San Juan-Chama Project water to water-short irrigation districts. In addition, reservoirs were re-regulated to use water supplies more efficiently.

Water Year 1990 Snow Water Equivalent

Trends for Upper Colorado Region



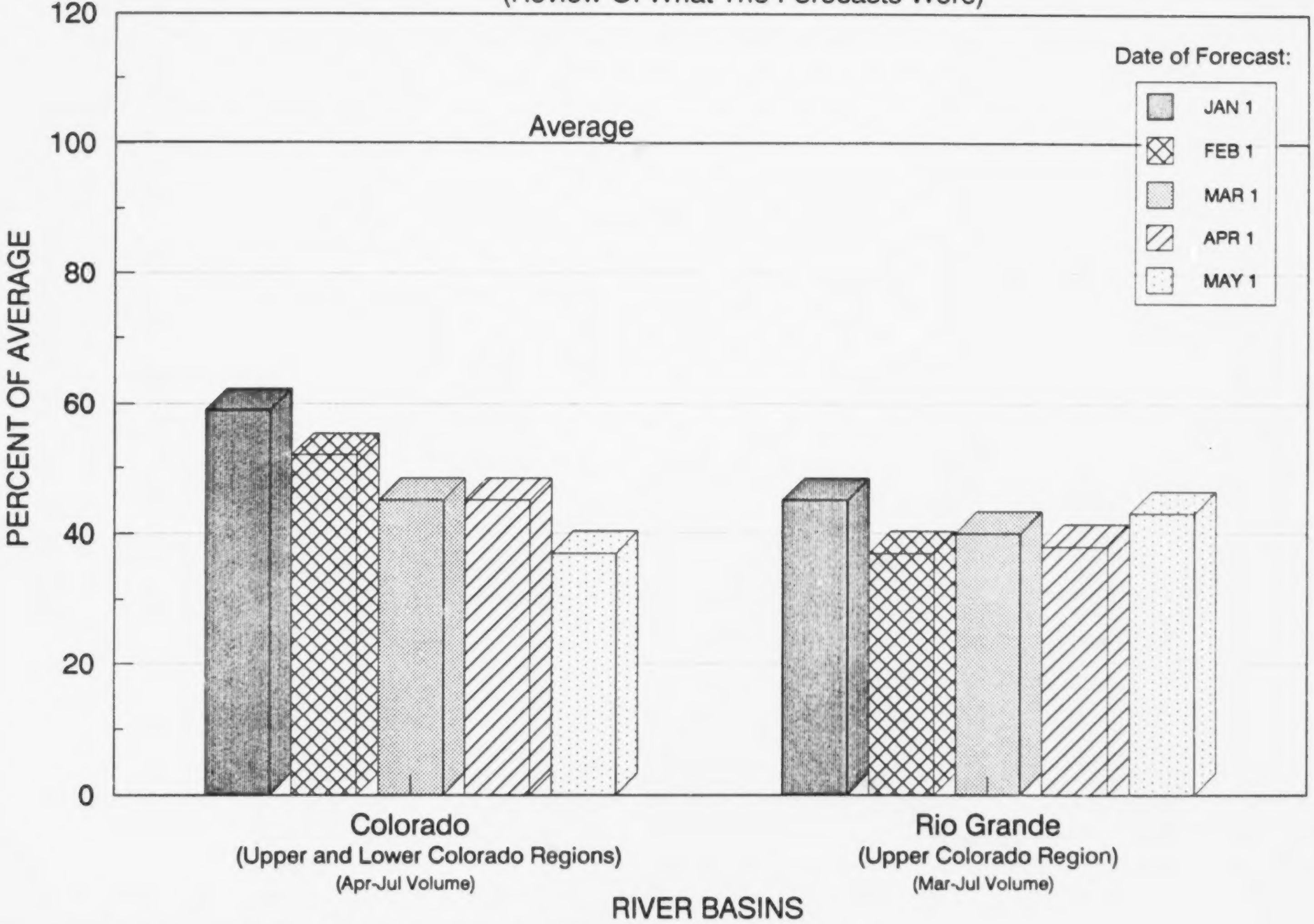
Notes : 1. Jan 1 includes only the San Juan Basin

2. Source : Soil Conversation Service Water Supply Outlook Reports for Individual States

Upper and Lower Colorado Regions

Water Year 1990 Streamflow Forecasts[1]

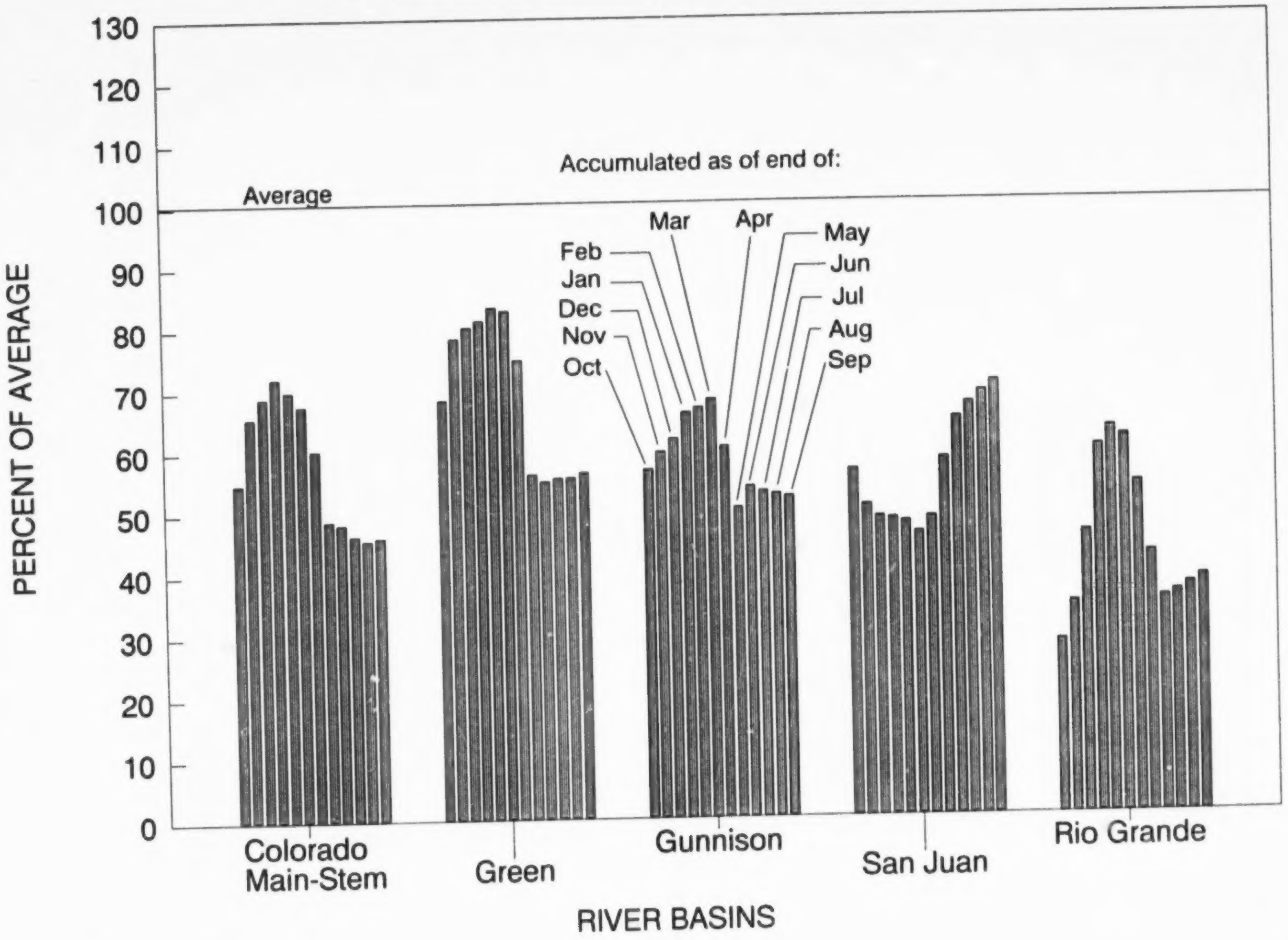
(Review Of What The Forecasts Were)



Note: 1. Data Source: "Water Supply Outlook For The Western U.S." By The Soil Conservation Service and National Weather Service

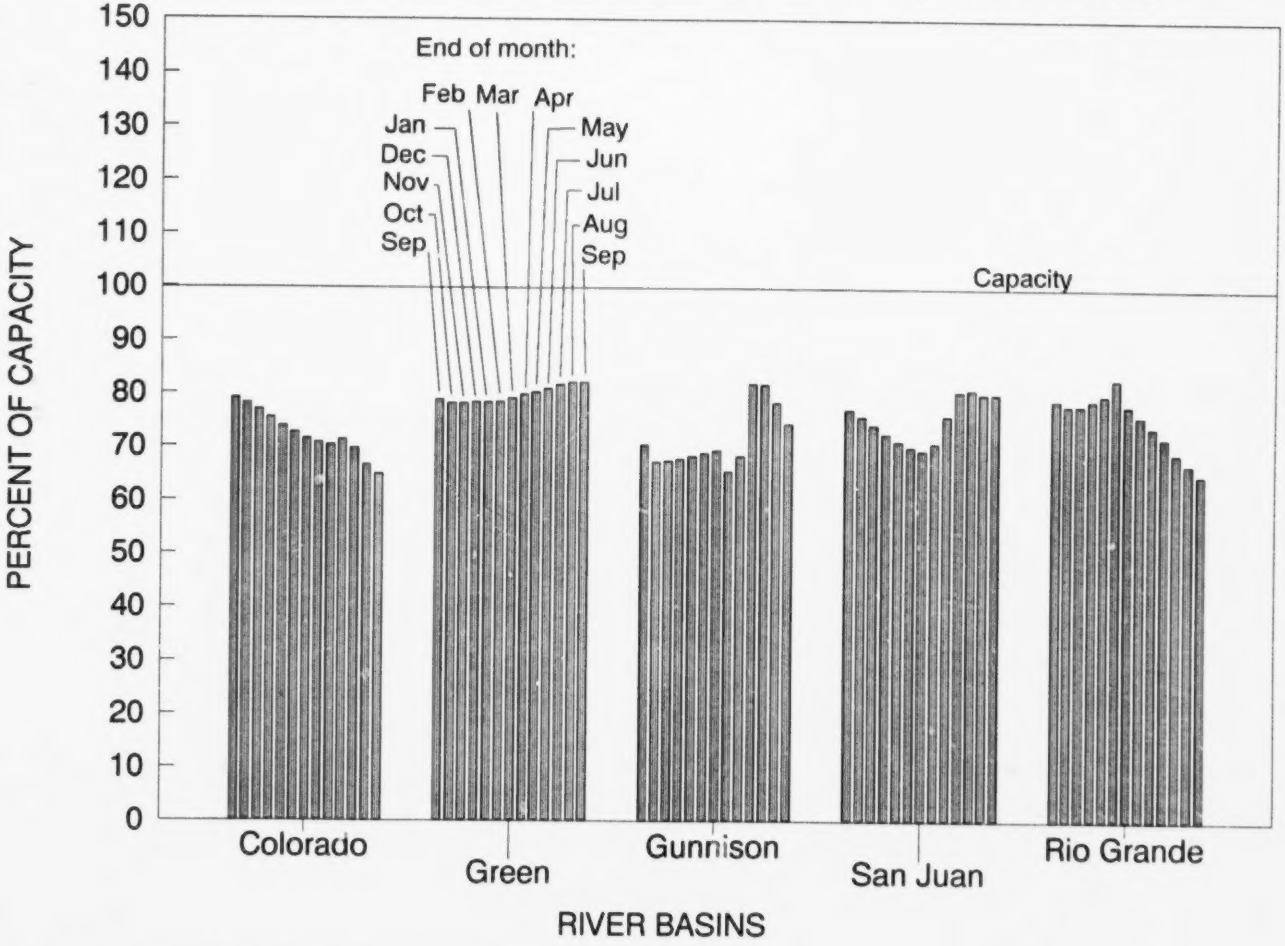
Water Year 1990 Accumulated Inflows, Upper Colorado Region

Percent of Average, October 1, 1989 to September 30, 1990

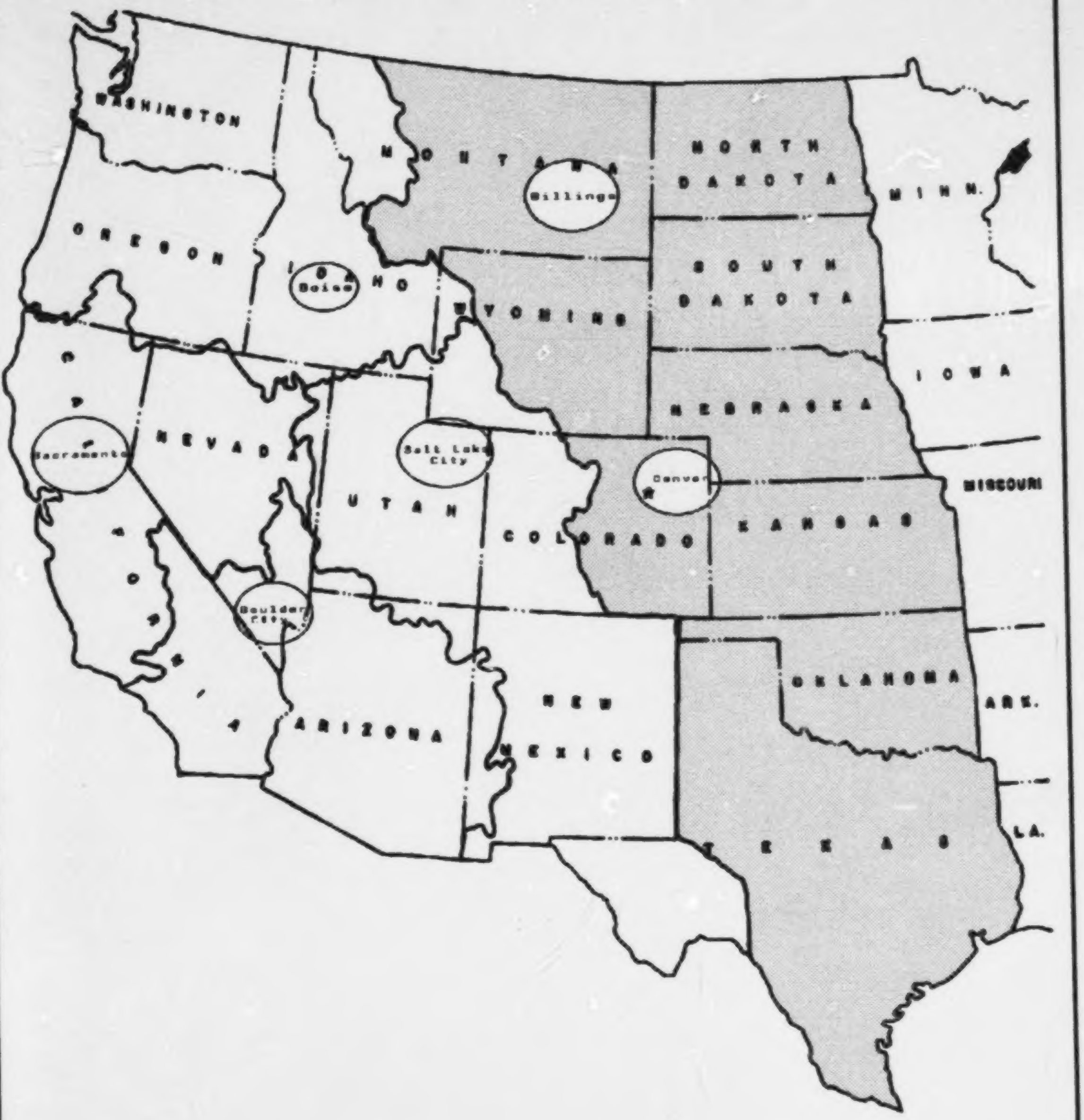


Water Year 1990 Reservoir Storage, Upper Colorado Region

Percent of Capacity[1], September 30, 1989 to September 30, 1990



Note: 1. Upper Colorado Region reports storage as a percent of capacity


WASHINGTON
OREGON
IDAHO
Boise
MONTANA
Billings
NORTH DAKOTA
SOUTH DAKOTA
MINN.
WYOMING
IOWA
NEBRASKA
CALIFORNIA
Sacramento
NEVADA
Salt Lake City
Denver
MISCOURI
UTAH
COLORADO
KANSAS
Boulder City
OKLAHOMA
NEW MEXICO
ARK.
ARIZONA
TEXAS
LA.

GREAT PLAINS REGION

ROGER K. PATTERSON, REGIONAL DIRECTOR
P.O. BOX 36900
BILLINGS, MONTANA 59107-36900

GREAT PLAINS REGION

This chapter summarizes water year 1990 water supply conditions and Reclamation's response to drought in the Great Plains Region. The Great Plains Region is Reclamation's largest region. It includes all of the states of North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma. In addition, it includes most of Montana, Wyoming, and Texas and about half of Colorado. It encompasses the Missouri River drainage and other tributaries to the Mississippi River and Gulf Coast.

Summary and Overview of Water Year 1990 Conditions

As varied as the Great Plains Region is in itself, so were the water supply conditions for water year 1990. The topographical differences of the plains and the Rocky Mountains provided a variety of major snowstorms; heavy, isolated rainfall; and periods of no moisture. From periods of both unusually warm and cold daily temperatures in the north to long spells of continued hot in the south, the region experienced a wide range of climatological and meteorological events throughout the year.

The northern portion of the region—the upper Missouri River basin—recovered slightly from the drought conditions of the previous years. Additional snow accumulations and spring rains provided much needed relief to the reservoirs and irrigations districts in this area. Several areas, primarily Clark Canyon Reservoir, were still significantly affected throughout the year. Although precipitation was near normal in 1990, upstream reservoirs and the overall effects of several years of sustained drought, the system was not able to recover and irrigation shortages were still experienced. Reservoirs in North Dakota, primarily Jamestown, were hindered by a lack of precipitation. Keyhole Reservoir, in Wyoming, was below normal for all of the year. The water levels in most of the reservoirs in the basin recovered to near normal levels by the end of the year.

Montana

Reclamation served on a State of Montana drought steering committee and helped develop a State drought policy. As part of the drought policy, a water advisory group was established for the Beaverhead River basin. Reclamation also assisted Montana's State Water Plan Advisory Council in developing policy and plans for water use and developing in the State.

Wyoming

Drought conditions since 1988 have depleted available storage in the North Platte Project. Several reservoirs reported record low storage content during the year, and reservoir storage remains at near record lows. Storage at most reservoirs is less than 50 percent of normal. North Platte Project storage ownerships are less than 3 percent of normal. Unless significantly above normal precipitation occurs in the winter and spring of 1991, additional shortages are expected for the 1991 irrigation season.

Colorado

Reservoir carryover storage in Lake Granby at the beginning of water year 1990 was 301,182 acre-feet, which was 188,318 acre-feet below the 30-year average of 419,500 acre-feet. After a below normal precipitation level in the winter, a wet March improved conditions. The April 1 snowpack increased to 93 percent of average, and the April-July runoff forecast volume increased to 180,000 acre-feet. With April inflow at 129 percent of average and May 1 snowpack at 90 percent of average, the runoff forecast volume rose to 195,000 acre-feet. Inflows increased sharply by the end of May and were at 1,303 ft^3/s on May 31. A total of 14,442 acre-feet of water was pumped into Lake Granby from May 16 through June 30 via Windy Gap Pumping Plant for the 1990 water year. The computed April to July natural inflow to Lake Granby totaled 200,300 acre-feet. Lake Granby ended water year 1990 with 295,791 acre-feet of water in storage. This was 120,109 acre-feet below average and 5,391 acre-feet less than last year. Adams Tunnel diversions totaled 216,800 acre-feet for the water year, or more than 17,800 acre-feet below average.

North and South Dakota

The drought throughout the plains areas continued to have an effect on storage content in most reservoirs in North and South Dakota. The water year began with storage contents at below normal levels. The lack of adequate snow and rainfall during the winter and spring did not allow reservoirs to fill to normal levels except for Shadehill and Deerfield Reservoirs. Many of the reservoirs reached only 60 to 70 percent of their normal high level for the year. Most reservoirs in North and South Dakota will require above normal precipitation in water year 1991 to fill to normal levels.

Special operations at Pactola Reservoir were made to ensure at minimum flow of 15 ft^3/s to Rapid Creek during the winter of 1990. With over 50 percent of Pactola's storage depleted, the established operating criteria called for a minimum release of 7 ft^3/s. Strong concern was raised by the South Dakota Game, Fish, and Parks Department and others, that this low release would result in a major fish kill in Rapid Creek. Through close coordination between Reclamation, the City of

Rapid City, the Rapid Valley Conservation District, and the South Dakota Department of Game, Fish and Parks Department, an agreement to provide higher winter releases, 11.5 ft^3/s, from Pactola was reached.

Flows in the James River below Jamestown Reservoir were reduced as a result of the low inflows. The reservoir remained at 60 percent of normal throughout the entire 1990 water year.

Keyhole Reservoir inflows were only 50 percent of normal. This, coupled with the need to divert water to Belle Fourche Reservoir, depleted available storage to about 25 percent of normal throughout the year.

Nebraska and Kansas

Water supply conditions throughout Reclamation projects in Nebraska and Kansas remained below normal for water year 1990. Although total precipitation was above average for 9 of the 16 reservoirs, heavy irrigation demands used all available inflows and continued to draw storage from reservoirs which were already at unusually low levels. With a reduced water supply, many of the irrigation districts experienced shortages during the 1990 irrigation season. Several of the reservoirs ended the 1990 water year with no active storage remaining or with only limited available storage. Due to the lack of supply, no irrigation deliveries were made from Cedar Bluff Reservoir for the twelfth consecutive year.

Many reservoirs experienced their lowest end-of-month storage content in a number of years. Listed below are specific recordings:

- Republican Basin - lowest end-of-November reservoir levels since 1980
- Box Butte - lowest end-of-November reservoir level since 1976
- Enders - lowest end-of-February reservoir level ever recorded
- Swanson - lowest end-of-February reservoir level since 1980
- Hugh Butler and Harlan County - lowest end-of-February reservoir levels since 1981
- Enders - lowest end-of-May reservoir level ever recorded
- Harlan County - lowest end-of-May reservoir level since 1981

By the end of the 1990 water year, reservoir storage was below normal. Winter and spring precipitation need to be well above normal to refill the reservoirs in order to provide a full service water supply during the 1991 irrigation season. If this does not occur, then another year of limited water supply and irrigation shortages can be expected in the Nebraska-Kansas projects area.

Texas and Oklahoma

During the early part of water year 1990, reservoirs in Texas and Oklahoma remained at near normal water surface elevations. However, conditions changed drastically in the spring as above normal rains engulfed Oklahoma and northern Texas. By the end of March, only four reservoirs in Texas were reporting below normal reservoir content.

Heavy rainfall in April pushed the four month (January to April) cumulative precipitation totals to above average annual values. McGee Creek reported 12.35 inches; Arbuckle reported 12.76 inches and Thunderbird Reservoir an equal amount. Most reservoirs began making flood control releases by the end of April. McGee Creek recorded record high reservoir elevation on March 18 and this record high level was exceeded again on April 19. Only three reservoirs in Texas—Choke Canyon, Sanford and Twin Buttes—had below normal storage content throughout the year. Temperatures during the summer in this area were typical with long hot and dry periods.

During May, heavy rains continued to fall. McGee Creek, Arbuckle, and Norman Reservoirs reached their maximum water surface elevation on record. In Oklahoma City, total rainfall for the first five month of the year were the highest of record. Flood control releases were continued from most of the reservoirs. All but four of the reservoirs in these areas had below normal content.

June came and so did hot and dry conditions. Temperatures rose quickly, exceeding 100° Fahrenheit in many areas. The Texas Panhandle had record high temperatures during the month of June, resulting in record high municipal releases from Lake Meredith. Conditions throughout the remainder of the year were hot and dry. Releases during this time were made to satisfy downstream demands.

All but four of the reservoirs in this area have above normal storage content at the end of the water year. The reservoirs should, with average precipitation and weather conditions, be able to provide adequate water supplies in 1991.

1990 Summary for Individual Projects

Pick-Sloan Missouri Basin Program

Boysen Unit.—Boysen Reservoir on the Bighorn River in Montana began the 1990 water year with a near-normal content of 663,997 acre-feet. Releases for power generation, irrigation, and the downstream river fishery drew the reservoir down to a low of 544,906 acre-feet on June 4. Winter snowfall was only about 70 percent of normal, and the April-September inflow was only 57 percent of normal. Summer reservoir content peaked on July 7 at 609,781 acre-feet, 76 percent of capacity. The supply of storage water was adequate to meet

592,615 acre-feet, 90 percent of normal. Inflow for the 1990 water year was 681,212 acre-feet, 65 percent of normal. Power generation for the year was 65.768 gigawatt hours, 82 percent of normal.

If 1991 inflows are near or above normal, Boysen should fill. However if lower decile inflows occur, the reservoir will only fill to 621,000 acre feet, 77 percent of capacity. The supply of storage water should be adequate for irrigation even if runoff is near the historic low. During the fall and winter, releases for power generation and the river fishery will only be about 60 percent of normal.

East Bench Unit.—Because of the persistent drought, storage in Clark Canyon Reservoir on the Beaverhead River in Montana was drafted at the beginning of the year to a critically low level of 45,790 acre-feet at elevation 5511.47. This was over 11.5 feet lower than at the beginning of water year 1989 and 36 percent of the long-term average. Because of the drought's impact on Clark Canyon's water supply, the 1989 irrigation season was discontinued approximately 6 weeks earlier than normal. After the Labor Day weekend, releases were reduced to maintain 50 ft^3/s in the Beaverhead River immediately below the dam. The release of 50 ft^3/s was maintained through April, the start of the irrigation season.

Mountain snowfall in the Beaverhead River basin started out below average. The January 1 snowpack conditions, as measured by the Soil Conservation Service, were 44 percent of normal. Snowpack conditions improved by April 1, but were still only 73 percent of normal. Warm temperatures in April generated above average snowmelt, particularly from low and mid-elevations. Snowpack conditions deteriorated and were only 41 percent of normal by May 1. Spring precipitation within the basin was near or slightly above normal.

The 1989 drought also had a critical impact on storage in Lima Reservoir. Lima Reservoir is a privately-owned irrigation facility located upstream of Clark Canyon Reservoir on the Red Rock River, a tributary of the Beaverhead River. Lima Reservoir has a total capacity of about 85,000 acre-feet. Lima Reservoir was essentially emptied by mid-July, 1989. Storage of Lima Reservoir on October 1 was 6,096 acre-feet or 20 percent of average. This resulted in much of the flow of the Red Rock River being stored in Lima Reservoir.

Mountain snowpack conditions of 41 percent of normal and low storage in Lima Reservoir combined to reduce forecasts of spring runoff into Clark Canyon Reservoir to an unusually low amount.

Annual inflow to Clark Canyon Reservoir during water year 1990 was the second lowest annual inflow since the reservoir was constructed in 1965, only greater than inflow during 1989. The October-April inflow averaged 56 percent of normal. In early spring, the East Bench Irrigation District held meetings to inform irrigators of projected water supplies and reduced irrigation allotments. Irrigators in the Beaverhead River Basin below Clark Canyon Reservoir used water conservatively during May and June. By July 1, the reservoir was drafted to 82,546 acre-feet at elevation 5524.45, 21.65 feet below normal full pool. Irrigation demands increased during July; and by the end of July about 20 percent of the irrigators on the East Bench unit had used their allotment of water for the season. Nearly all of the remaining irrigators used their allotment of water by the second or third week of August.

The total annual inflow to Clark Canyon Reservoir during 1990 was 130,000 acre-feet, only 45 percent of normal. Inflows to Clark Canyon Reservoir have been well below normal since December 1987 with the 3 lowest inflows on record occurring during 1988, 1989, and 1990.

Based on end of September storage, Clark Canyon Reservoir would be expected to fill to the top of the joint-use pool at elevation 5546.1 only under high runoff conditions. Storage of Clark Canyon Reservoir would be expected to fill to 155,000 acre-feet at elevation 5541.5 during a normal runoff year. This would be about 23,000 acre-feet or 4.6 feet below the top of the joint-use pool. Storage under normal runoff conditions would be adequate to satisfy irrigation demands during the 1991 irrigation season. Storage would be expected to fill to 130,000 acre-feet at elevation 5536.2 under low runoff conditions. This would be about 48,000 acre-feet or 9.9 feet below the top of the joint-use pool. Low runoff probably would result in shortage of irrigation water during the end of the 1991 irrigation seasons. This is partially due to the low levels of Lima Reservoir, a private irrigation reservoir located upstream of Clark Canyon Reservoir. Annual runoff during 1988, 1989, and 1990 was less than the lower decile flow used to define low runoff conditions.

Winter river releases would be maintained to allow 50 ft^3/s in the Beaverhead River for both the low runoff condition and normal runoff condition. Although a release of 50 ft^3/s to the Beaverhead River is less than an optimum winter release for the Beaverhead River fishery, Reclamation continues to cooperate with the Montana Department of Fish, Wildlife, and Parks and with Trout Unlimited to determine a suitable minimum release during drought conditions. Winter releases would increase to about 200 ft^3/s for high runoff conditions to benefit the fishery of the Beaverhead River.

Moisture conditions in the Beaverhead River basin in Montana, have been critically low for the past 3 years. Below-normal snowpack, low carryover storage, and the need to fill two privately-owned reservoirs led to record-low inflows. Storage was at an all-time low, and by September 1, 1990, most users were out of water. At the end of the water year, storage in Clark Canyon Reservoir was 29 percent of normal.

Consequently, East Bench Irrigation District allocated water to its users. Reclamation has worked closely with the State, Trout Unlimited, and irrigation users to establish a minimum river release from Clark Canyon Reservoir to the Beaverhead River for the nonirrigation season. Flows will be 50 ft^3/s throughout users to establish a minimum river release from Clark Canyon Reservoir to the Beaverhead River for the nonirrigation season. Flows will be 50 ft^3/s throughout fall and winter 1990-1991, reduced from 100 ft^3/s during the 1990 irrigation season. Reduced flows will be maintained until the reservoir refills to normal levels or until the 1991 irrigation season begins.

Riverton Unit.—Bull Lake on Bull Creek in the Wind River basin in Wyoming contained 107,615 acre-feet, or 114 percent of normal, at the start of water year 1990; but, winter snowfall was well below normal. April through September inflow was 82 percent of normal. Reservoir content peaked August 3 at 141,433 acre-feet, 93 percent of capacity. This year, the tribes of the Wind River Indian Reservation dedicated a portion of their reserved water right to an instream flow in the Wind River. This dedication reduced the amount of natural flow available for diversion by Midvale Irrigation District, which resulted in increased demand for stored water from Bull Lake. The water supply for Midvale Irrigation District was adequate during the entire irrigation season, but the increased demand for Bull Lake storage resulted in reservoir levels lower than first anticipated. September 30, 1990 content was 83,513 acre-feet, 88 percent of normal. Inflow for the 1990 water year was 170,488 acre-feet, 84 percent of normal.

Bull Lake began water year 1991 with a content of 83,513 acre-feet, or 88 percent of normal. If 1991 inflows are near or above normal, Bull Lake would be expected to fill and have an adequate water supply for irrigation. However if lower inflows occur and a Wind River instream flow of 252 ft^3/s is maintained, the reservoir will only fill to about 100,000 acre-feet, about two-thirds full. If that occurs, the water supply would not be adequate to meet all irrigation needs, and the reservoir would be drafted to an unusually low level by the end of the year.

Continuing drought has limited available reservoir storage in the Wind River Basin. In addition, non-Indian water users on the Wind River Reservation have been affected by the June 1989 award of 500,000 acre-feet of water to the Wind River Tribes, and the Tribes' dedication of 252 ft^3/s to instream flows. Non-Indian irrigators near Crowheart received an insufficient water supply for most of the irrigation season. Midvale Irrigation District, the largest irrigation user on the reservation, supplemented its diversions with releases from Bull Lake Reservoir. The combination of limited reservoir storage and the maintenance of an instream flow created irrigation shortages in the basin.

Reclamation encouraged Midvale to operate the Riverton Unit to meet its legal obligations to the State and the Tribes within the limits of available water. The operating guidelines for Bull Lake and Pilot Butte Reservoirs were changed to emphasize storage use in Pilot Butte and storage conservation in Bull Lake. The changes increased the water supply by allowing Pilot Butte Reservoir to capture more of the available flow in the Wind River. The changes also raised the water level in Bull Lake, thus improving the fishery, as desired by the Wind River Tribes and the U.S. Fish and Wildlife Service.

Canyon Ferry Unit.—Much needed precipitation fell during August and September of 1989. At the beginning of the year, storage in Canyon Ferry Lake on the Missouri River in Montana was 1,452,002 acre-feet at elevation 3781.08. At 82 percent of normal, this was 38,115 acre-feet and 1.30 feet higher than the previous year at this same time. Fall and winter inflows to Canyon Ferry were about 80 percent of normal. To conserve storage, turbine release were maintained between 2,700 and 3,200 ft^3/s during October and November. A combination of lower than normal releases, good fall moisture, reduced irrigation demands, and increased return flows, allowed storage to slowly increase to 1,595,189 acre-feet at elevation 3785.80 on December 7, 1989.

With storage near 90 percent of normal by the end of November, turbine releases were increased from 3,200 ft^3/s to 4,000 ft^3/s on December 2, 1989. On January 1, 1990, the Soil Conservation Service measured snowpack conditions in the Missouri River Basin above Canyon Ferry Lake to be about 70 percent of normal. By February 1, they had increased to 82 percent of normal and essentially remained near this level through April. Based on the runoff forecasts prepared from snowpack and precipitation data, winter releases were maintained near 4,000 ft^3/s through most of April. On April 3, storage was drafted to an annual low of 1,357,962 acre-feet at elevation 3777.79 feet. However, by May 1, the snowpack conditions had declined to about 53 percent of average.

In early April, meetings were held with the Montana Department of Fish, Wildlife, and Parks to discuss proposed operations of Canyon Ferry Reservoir. With mountain snowpack rapidly deteriorating, it was mutually agreed to reduce the turbine releases from Canyon Ferry to desirable rates which would sustain flows in the Missouri River at 3,000 ft^3/s in order to conserve storage in Canyon Ferry.

Storage in Canyon Ferry began to steadily increase in early April. By maintaining lower than normal turbine releases from Canyon Ferry, storage slowly increased to the peak for the year 1,866,486 acre-feet at elevation 3794.37 feet on July 8. This was 96 percent of the normal full pool level, or 85,573 acre-feet and 2.63 feet below the top of the joint-use pool. Actual April-July runoff into Canyon Ferry was 58 percent of normal totaling 1,205,807 acre-feet, 15,678 acre-feet less than in 1989.

Warm, dry weather during August and September caused storage in Canyon Ferry to slowly decline to about 1,618,123 acre-feet at elevation 3786.54 by the end of the year. This is about 90 percent of normal and 333,936 acre-feet or 10.46 feet below the top of the joint-use pool. This is also 166,121 acre-feet more than at this same time a year ago. Annual runoff into Canyon Ferry totaled 2,749,860 acre-feet and was 68 percent of normal.

Based on the end of September storage level, Canyon Ferry Reservoir would be expected to fill to the top of the joint-use pool at elevation 3797 feet by the end of June under each of the three various runoff conditions. A river flow of 4,000 ft^3/s is considered the desired minimum flow in the Missouri River downstream of

Canyon Ferry for fishery. Only under the low runoff conditions, river releases may drop below 4,000 ft^3/s in order to allow the reservoir to fill. This would occur during the early spring runoff and it is expected that downstream tributary flows would offset the lower releases out of Canyon Ferry and allow the Montana Power Company to maintain a minimum release of 4,000 ft^3/s below their powerplants to the Missouri River.

During 1990, Canyon Ferry powerplant generated 284,911,000 kilowatt-hours. This is the third lowest generation since 1963 and only 70 percent of the long-term average. It is also 8,742,000 kilowatt-hours more than generated in 1989. The plant used 93 percent of the water released from the dam in 1990. The remainder of the water released was to meet the irrigation needs of the Helena Valley Irrigation District. The average power generation produced at Canyon Ferry Powerplant is 404.1 million kilowatt-hours. If runoff conditions are dry, power generation produced at Canyon Ferry Powerplant during 1991 would be about 80.1 million kilowatt-hours less than 1990.

Lower Marias Unit.—Above normal precipitation fell during August and September of 1989. At the beginning of water year 1990, storage in Lake Elwell (on the Marias River in Montana) was 838,655 acre-feet at elevation 2985.37 feet. At 107 percent of normal, this was 140,836 acre-feet and 9.48 feet higher than last year at this same time. October through April inflows into Lake Elwell were about 175 percent of normal. The October through January inflows were the highest of record totalling nearly 2.50 times greater than normal. November inflows were 79,535 acre-feet or 386 percent of normal, the highest November inflow of record. To evacuate storage, releases were increased to 1,000 ft^3/s in early December and maintained at this rate during the winter. This flow is considered to be the maximum desired winter release. Because of the warmer weather experienced during the winter, this flow did not cause ice jam problems downstream. This release allowed storage to be drafted to the low for the year of 764,849 acre-feet at elevation 2980.58 feet on April 1, 1990. This was 4.58 feet above the top of the active conservation pool or the normal winter drawdown level. Even with these high releases storage was not successfully evacuated to elevation 2976.00 by the end of February because of the record high fall runoff.

On January 1, the Soil Conservation Service measured snowpack conditions in the Marias River Basin above Lake Elwell to be 86 percent of normal. By February 1 the snowpack conditions had increased to 120 percent and had only declined to 108 percent by April 1.

In early April, meetings were held with the Montana Department of Fish, Wildlife, and Parks and the Marias Management Committee to discuss proposed operations of Lake Elwell. It was agreed to reduce the releases from Lake Elwell to 750 ft^3/s to allow the reservoir to quickly refill. Inundating new shoreline prior to April 15 provided the opportunity to enhance the fishery habitat for fish spawning.

Warm weather caused snowmelt runoff into Lake Elwell to increase in April. Inflows into Lake Elwell in April were 100,316 acre-feet or 151 percent of normal, the third highest April inflow of record. Storage began to slowly increase in early April. To control the rate of fill, releases were gradually increased from 750 ft³/s in mid-May to 1,650 ft³/s in early June. Inflows from the spring runoff peaked at 5,064 ft³/s on May 31. Storage continued to increase until it reached a peak for the year of 958,628 acre-feet at elevation 2992.51 feet on July 5. This is the highest reservoir level since 1975 and 100 percent of the normal full pool, only 0.49 feet and 8,691 acre-feet below the top of the joint use pool. Releases were gradually reduced in early September to 930 ft³/s. Actual April-July runoff into Lake Elwell totaled 443,177 acre-feet or 88 percent of normal, only 555 acre-feet less than in 1989. The total annual runoff into Lake Elwell was 740,778 acre-feet and was 108 percent of normal.

Storage in Lake Elwell was slowly drafted to 807,003 acre-feet at elevation 2983.36 feet at the end of water year 1990. This is about 98 percent of normal and 160,000 acre-feet or 9.64 feet below the top of the joint use pool. This is 31,652 acre-feet less that at this same time a year ago.

Based on the end of September 1990 storage level, Lake Elwell would fill to the top of the joint use pool at elevation 2993 feet by the end of June 1991 under the normal and high runoff conditions, but it would not fill under the low runoff conditions since a minimum flow of 500 ft³/s is being maintained. Under all three conditions, a minimum river release of 500 ft³/s, a flow considered to be the desired minimum flow in the Marias River below Tiber Dam for the fishery, is being maintained. If two back-to-back years of low runoff conditions occurred, the river releases would need to be reduced to between 250 and 300 ft³/s to conserve storage.

There is no large demand for the storage in Tiber Reservoir; therefore, river releases from Tiber Dam in 1991 would be maintained at 500 ft³/s to benefit the fishery even though the reservoir would not fill.

Yellowtail Unit.—Storage in Bighorn Lake on the Bighorn River in Montana was slowly drafted to 988,255 acre-feet at elevation 3632.87 by the end of water year 1990. This is about 97 percent of normal and 81,774 acre-feet or 7.13 feet below the top of the joint-use pool. This is also 104,909 acre-feet more than at this same time a year ago.

Based on the end of September storage level, Bighorn Lake would be expected to fill to the top of the joint-use pool at elevation 3640 feet by the end of July under each of the three various runoff conditions—low, average, and high. A river flow of 2,000 ft³/s is considered the desired minimum flow in the Bighorn River downstream of the Yellowtail Afterbay Dam for fishery. Under all three runoff conditions, this minimum flow of 2,000 ft³/s could be maintained all year.

The average power generation produced at Yellowtail Powerplant is 967.7 million kilowatt-hours. If runoff conditions are dry, power generation produced at Yellowtail Powerplant during 1991 would be about 295 million kilowatt-hours less than average.

Sun River Project

Gibson Reservoir on the Sun River in Montana began the 1990 water year with a content of 70,999 acre-feet, 240 percent of normal. Inflow for the year was above normal and irrigation water supplies were adequate all season. Gibson Reservoir is expected to fill under all three potential runoff conditions. If inflows are near to above normal, irrigation water supplies are expected to be adequate. However, if lower inflows occur, irrigation supplies will be somewhat limited during the latter part of the season.

Milk River Project

Storage in Sherburne Reservoir on Swiftcurrent Creek in Montana was 25,687 acre-feet at the beginning of the water year, the second highest end of September storage since 1955, and remained plentiful all season. By the end of September, storage was about 84 percent more than normal. Fresno Reservoir on the Milk River in Montana began the water year with a storage content of 49,836 acre-feet, 80 percent of normal, and ended the year at 91 percent of normal. An adequate water supply was available during the 1990 irrigation season.

Nelson Reservoir (offstream dikes in Montana) began the water year with a storage content of 37,030 acre-feet, 65 percent of average. By the end of February, storage had decreased to 54,607 acre-feet, about average. Storage was 73,337 acre-feet by the end of May, and began decreasing due to irrigation demand. Storage was 61,156 acre-feet by the end of September, slightly above average.

Storage of Sherburne Reservoir was drafted to 18,795 acre-feet at elevation 4749.73 by the end of water year 1990. This is about 84 percent greater than normal and 49,000 acre-feet or 38.2 feet below the top of the conservation pool. Sherburne Reservoir storage was about 6,900 acre-feet less than at the same time a year ago. Storage of Fresno Reservoir was about 43,089 acre-feet at elevation 2557.9 by the end of water year 1990. This is about 91 percent of normal and 60,300 acre-feet or 17.2 feet below the top of the conservation pool.

Based on the end of September storage, Sherburne Reservoir would be expected to fill only under high runoff conditions. Although an adequate water supply is available to fill Sherburne Reservoir under normal runoff conditions, Sherburne Reservoir water would be transferred to the Milk River to satisfy irrigation demands on the Milk River below Fresno Reservoir. Runoff into Sherburne

Reservoir under low runoff conditions would be only slightly greater than the amount of water transferred to the Milk River and storage would not exceed about 25,000 acre-feet and would essentially be depleted by the end of August, 1991.

Fresno Reservoir would be expected to fill under both high runoff conditions and normal runoff conditions. Under low runoff conditions, Fresno Reservoir would not fill and irrigation shortages would occur during August and September 1991. Shortage of irrigation water would have occurred during June and July under low runoff conditions but would be avoided because about 40,000 acre-feet of storage in Nelson Reservoir would be available for irrigation. Storage in Nelson Reservoir during both high runoff conditions and normal runoff conditions would be similar to storage during 1990. Storage of Nelson Reservoir would be drafted to the top of the inactive pool under low runoff conditions to satisfy irrigation demands of the lower Milk River Project.

Shoshone Project

Storage in Buffalo Bill Reservoir on the Shoshone River in Wyoming began water year 1990 with 221,466 acre-feet at elevation 5328.60 feet. This storage content was 88 percent of normal for the end of September and 86,564 acre-feet greater than on September 30, 1988.

The October through March inflows to Buffalo Bill Reservoir were 94 percent of normal totalling 104,148 acre-feet. As the 1989 irrigation season wound down, storage was slowly drafted to 200,488 acre-feet at elevation 5323.62 feet on October 19, 1989. All irrigation deliveries were discontinued on October 21. At that time river releases to the Shoshone River were reduced to 250 ft^3/s to allow for construction work to proceed on the modification of Buffalo Bill Dam and powerplants. This release rate was maintained through April 10 at which time they were increased to meet irrigation demands. During the fall, winter, and early spring, storage in Buffalo Bill Reservoir slowly increased to 249,946 acre-feet at elevation 5334.73 feet by April 22.

The Wyoming Game and Fish Department, requested specific river releases out of Buffalo Bill Dam in early May to assist them with performing special fish studies in the Shoshone River. As the river releases were gradually increased from 250 ft^3/s in early April to 2,535 ft^3/s on May 11, storage rapidly declined to 194,971 acre-feet at elevation 5322.24 on May 23. These were releases in excess of normal irrigation demands but contributed significantly to refilling Bighorn Lake to near elevation 3605 feet prior to Memorial Day weekend. At the conclusion of the special fish studies, river releases from Buffalo Bill were gradually reduced to about 1,300 ft^3/s during May 17-23 to meet irrigation demands.

At the request of the Bighorn Basin Projects Office in Cody, Wyoming, an objective in the summer operations of Buffalo Bill Reservoir was to prevent making any releases through the spillway. This would avoid interfering with construction work within the spillway. Therefore Buffalo Bill Reservoir was operated with the objective of filling the reservoir to no higher than elevation 5354 feet by the end of June, about 6 feet below the top of the conservation pool. On July 4, storage in Buffalo Bill Reservoir reached a peak for the year of 362,263 acre-feet at elevation 5354.48 feet, 5.52 feet below the top of the conservation pool.

To accommodate construction of spillway gates during the winter of 1990-91, storage in Buffalo Bill Reservoir was required to be evacuated to elevation 5315 feet by the end of October. However, above normal irrigation demands during the fall resulted in storage being drafted to 162,583 acre-feet or elevation 5313.39 feet by the end of the year, about 65 percent of normal.

Total energy generated at the Heart Mountain powerplant during 1990 was 23,636,000 kilowatt-hours. This was 3,063,000 kilowatt-hours less than generated in 1989 and 57 percent of the long-term average.

Following construction of the spillway gates, storage in Buffalo Reservoir will be allowed to fill to the new storage level at elevation 5393.5 feet. However, since funds are not available to complete construction of the recreation areas around Buffalo Bill Reservoir, the filling of the reservoir in water year 1991 will be limited to no higher than elevation 5365 feet. Until funds become available to complete the new recreation areas, this elevation would permit use of the existing recreational sites with no impacts.

The construction of the spillway gates is expected to be completed in late January. Based on the end of September storage level, Buffalo Bill Reservoir would be expected to fill to elevation 5365 feet by the end of June, except under the low runoff conditions. After construction of the spillway gates is completed, all powerplant releases through the Heart Mountain Powerplant would be discontinued during February and March to begin refilling Buffalo Bill Reservoir and assure adequate storage to meet irrigation demands for 1991. During this time, a minimum flow of 100 ft^3/s would be maintained for downstream fisheries.

The average power generation produced at Heart Mountain Powerplant is 41.3 million kilowatt-hours. Due to special operations to allow for ongoing construction work, power generation produced at Heart Mountain Powerplant during 1991 would be affected. Under all runoff conditions, generation is expected to vary from 2.5 to 5.5 million kilowatt-hours less than normal.

Construction of the Shoshone and Buffalo Bill Powerplants is expected to be completed sometime in January, 1991. Operation of these powerplants may affect the amount of generation produced from storage in Buffalo Bill Reservoir. Once all powerplants are in service, the power releases from Buffalo Bill Reservoir will be dependent upon the most efficient powerplant operation of the individual plants.

North Platte Project

The lack of available storage, coupled with below normal precipitation in the North Platte Project in Wyoming, prevented some irrigation districts from providing a full water supply during 1990. To equitably distribute water shortages, North Platte project water was allocated to users. Because of sufficient precipitation in May, water users did not use storage water during May and most of June, thus helping existing water supplies last through the irrigation season.

Reclamation informed water users about water supplies and anticipated shortages and encouraged water conservation through news releases and meetings.

To protect storage water for the North Platte Project, Wyoming's State Engineer agreed to regulate all junior water rights above Pathfinder Dam for Pathfinder Reservoir's 1904 water right.

Pathfinder Reservoir and Seminoe Reservoir were at their lowest end-of-July storage in 20 years and 23 years, respectively. Because of low water levels, archeological resources were vulnerable to damage. Reclamation worked closely with the Bureau of Land Management to protect these resources.

Colorado-Big Thompson Project

Completed in 1950, Granby Reservoir on the upper Colorado River collects and stores most of the project water supply for the Colorado-Big Thompson (CBT) Project. Reservoir carryover storage into water year 1990 was 301,182 acre-feet which was 188,318 acre-feet below the 30-year average of 419,500 acre-feet.

January precipitation was much below normal at 39 percent of average and reservoir inflow was 78 percent of average. October to January precipitation was 75 percent of average and the October to January inflow was 73 percent of average. The required minimum reservoir release of 20 ft^3/s for fish habitat was maintained throughout the October to January period.

The February 1 snowpack water content was recorded at 74 percent of average, resulting in a April to July runoff forecast of 165,000 acre-feet. February was continued dry at 80 percent of normal precipitation, and 90 percent of average inflow. The March 1 snowpack water content was 78 percent of average which slightly increased the April to July runoff forecast to 170,000 acre-feet. Wet conditions occurred in March, as precipitation was 205 percent of average. April 1 snowpack increased to 93 percent of average, and the April-July runoff forecast volume increased to 180,000 acre-feet.

Adams Tunnel diversions to the east slope and reservoir storage remained near capacity and close to plan through March 16, and were 132 percent of average. The diversions were shut down for 27 days on March 17 due to scheduled maintenance on Olympus Tunnel and Pole Hill Powerplant, Afterbay, and Power Canal. Marys Lake Powerplant annual maintenance and Lake Estes silt removal were also conducted during this time.

Lake Granby storage continued to decline until March 16 when minimum storage for the year was reached at 136,680 acre-feet (water surface elevation 8206.36 feet.) Granby storage continued to be below normal as the March 31 storage level was 167,839 acre-feet below the 1960-1898 average.

Due to much above normal precipitation, April inflow was high at 129 percent of average. April was a wet month as precipitation was 126 percent of average. The May 1 snowpack was 90 percent of average and with the increased precipitation this further increased the April through July runoff forecast volume to 195,000 acre-feet. Inflows rose sharply by the end of May and were at 1,303 ft^3/s on May 31.

With water pumped from Willow Creek and natural inflow on the rise, storage began a gradual climb reaching 185,414 acre-feet by May 31. May continued to be wet as precipitation was 124 percent of average.

Adams Tunnel diversions were only 35 percent of average in June to take full advantage of "skim" water on the Big Thompson River and project deliveries were below normal.

During July, Adams Tunnel diversions were 50 percent of average at 10,000 acre-feet to meet project water deliveries which were much below average to maintain desirable storage levels in Carter Lake and Horsetooth Reservoirs, and to take full advantage of "skim" water. For August, diversions through Adams Tunnel continued low at 6,900 acre-feet for the month to maintain terminal reservoir storage and to meet below normal irrigation deliveries. August inflows were 84 percent of average and precipitation was 86 percent of average.

During September, natural inflows were 114 percent of average, and precipitation was 119 percent of average. Adams Tunnel diversions continued low at 7,400 acre-feet for the month, 43 percent of average.

A total of 14,442 acre-feet of water was pumped into Lake Granby from May 16 through June 30 via Windy Gap Pumping Plant for the 1990 water year.

The computed April to July natural inflow to Lake Granby totaled 200,300 acre-feet. This was near the May 1 most probable (195,000 acre-feet) runoff forecast for the April-July volume.

Lake Granby ended water year 1990 with 295,791 acre-feet of water in storage. This was 120,109 acre-feet below average and 5,391 acre-feet less than last year. Adams Tunnel diversions totaled 216,800 acre-feet for the water year, or more than 17,800 acre-feet below average.

Drought-related Fish and Wildlife Enhancement Actions

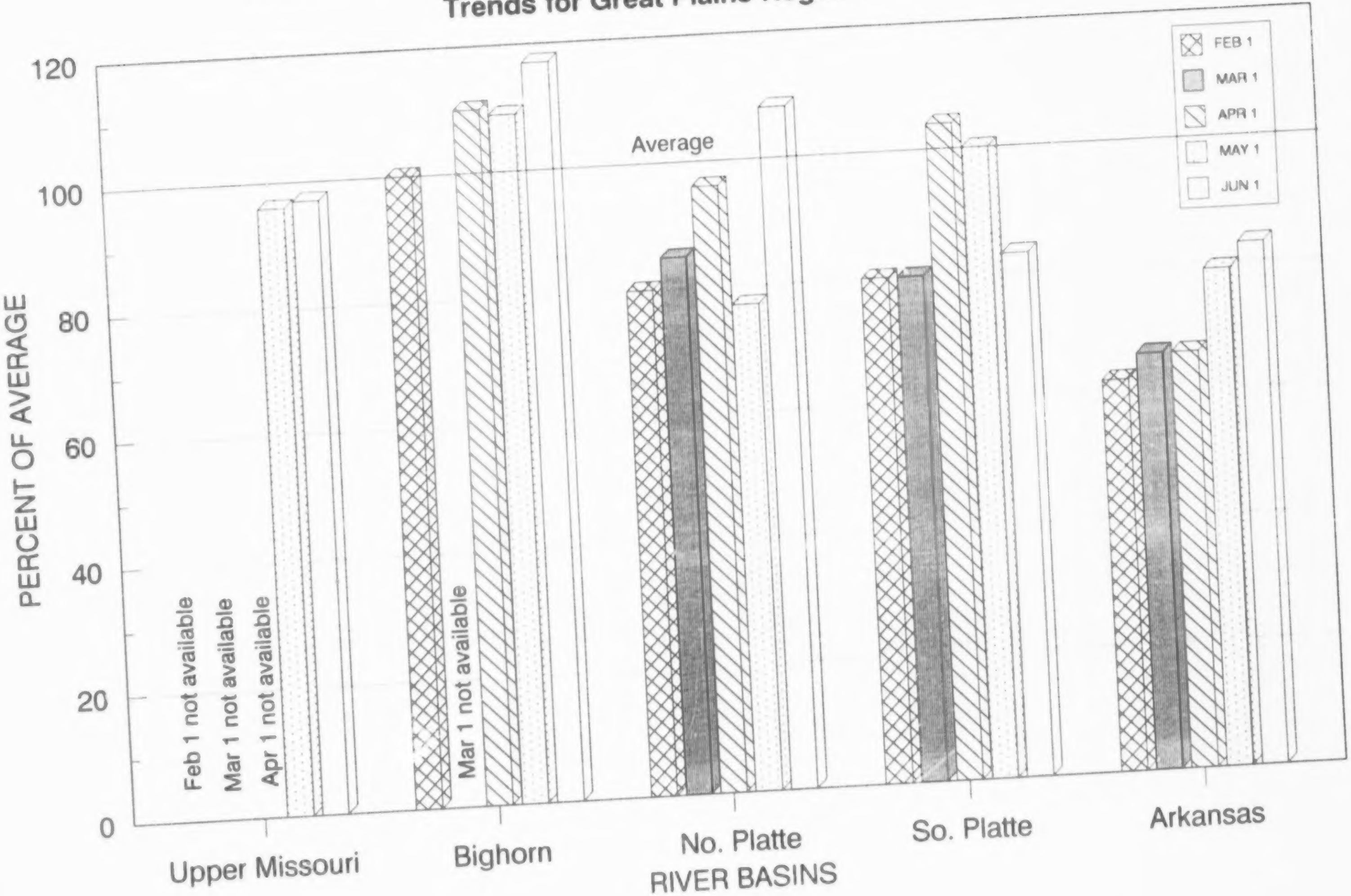
Drought conditions caused many of North Dakota's marshes and wetlands to dry out, resulting in a significant loss of habitat for wildlife. Reclamation, in cooperation with the U.S. Fish and Wildlife Service, released water to the dry bed of Lake Williams, an important nesting habitat for the threatened piping plover. Releases began April 27, 1990, and continued until 450 acre-feet of water was supplied (a depth of about 6 inches).

About 1,500 acre-feet of water was released from the McClusky Canal into numerous pools in the Turtle Lake and Koenig wildlife mitigation areas. Water from the McCluskey Canal was also pumped into two privately-owned wetlands.

At Box Butte Dam in Nebraska, which has experienced persistent water supply shortages, the Mirage Flats Irrigation District agreed to reduce deliveries to maintain a higher minimum level in the reservoir. To compensate, the irrigation district used mitigation funds from the Nebraska Game and Parks Commission to improve the efficiency of the delivery system. Higher water levels in the reservoir not only maintain the fishery in the reservoir but also enhance the area for waterfowl and other wildlife.

Water Year 1990 Snow Water Equivalent

Trends for Great Plains Region

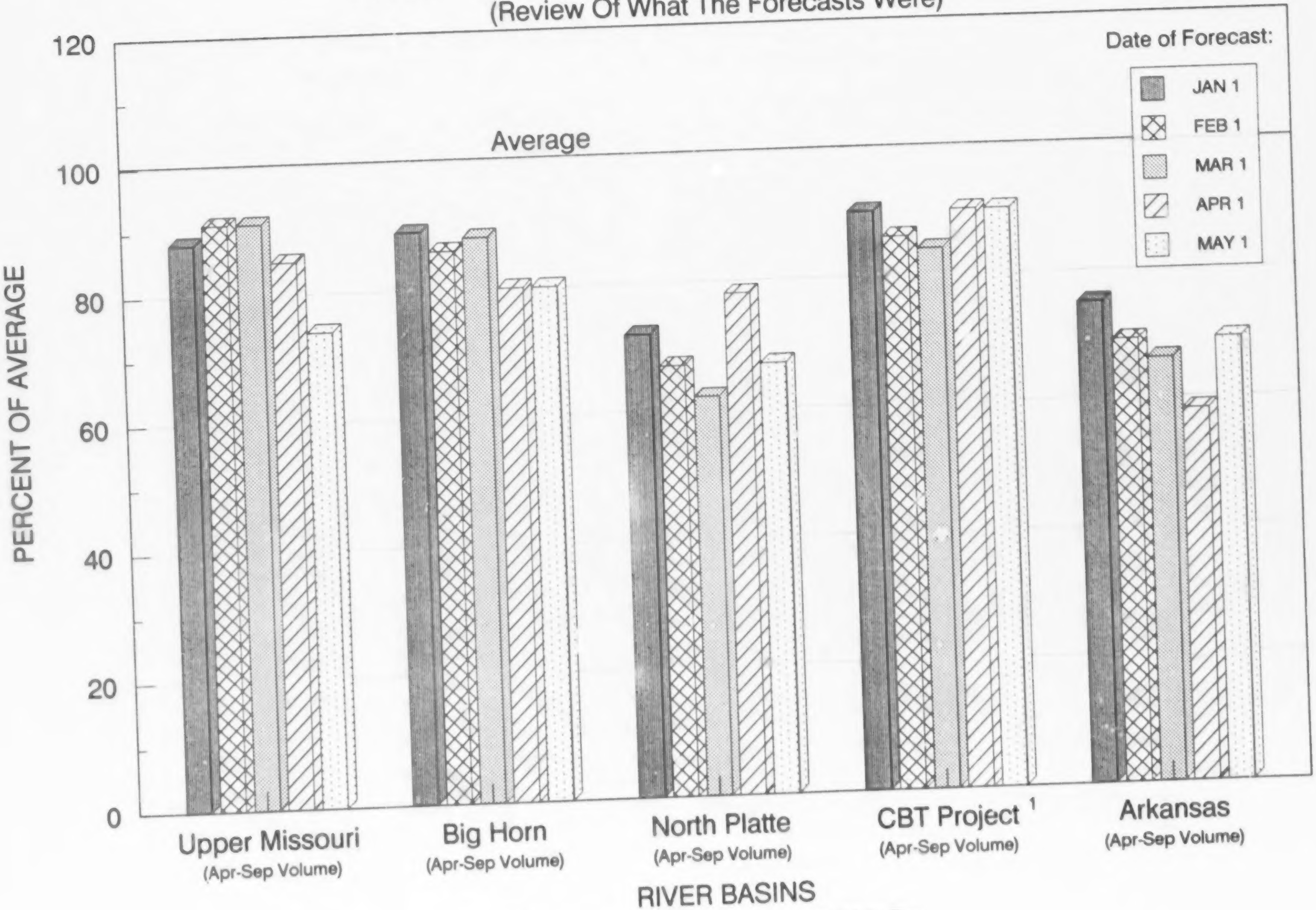


Source : Soil Conservation Service Water Supply
Outlook Reports for Individual States

Great Plains Region

Water Year 1990 Streamflow Forecasts[2]

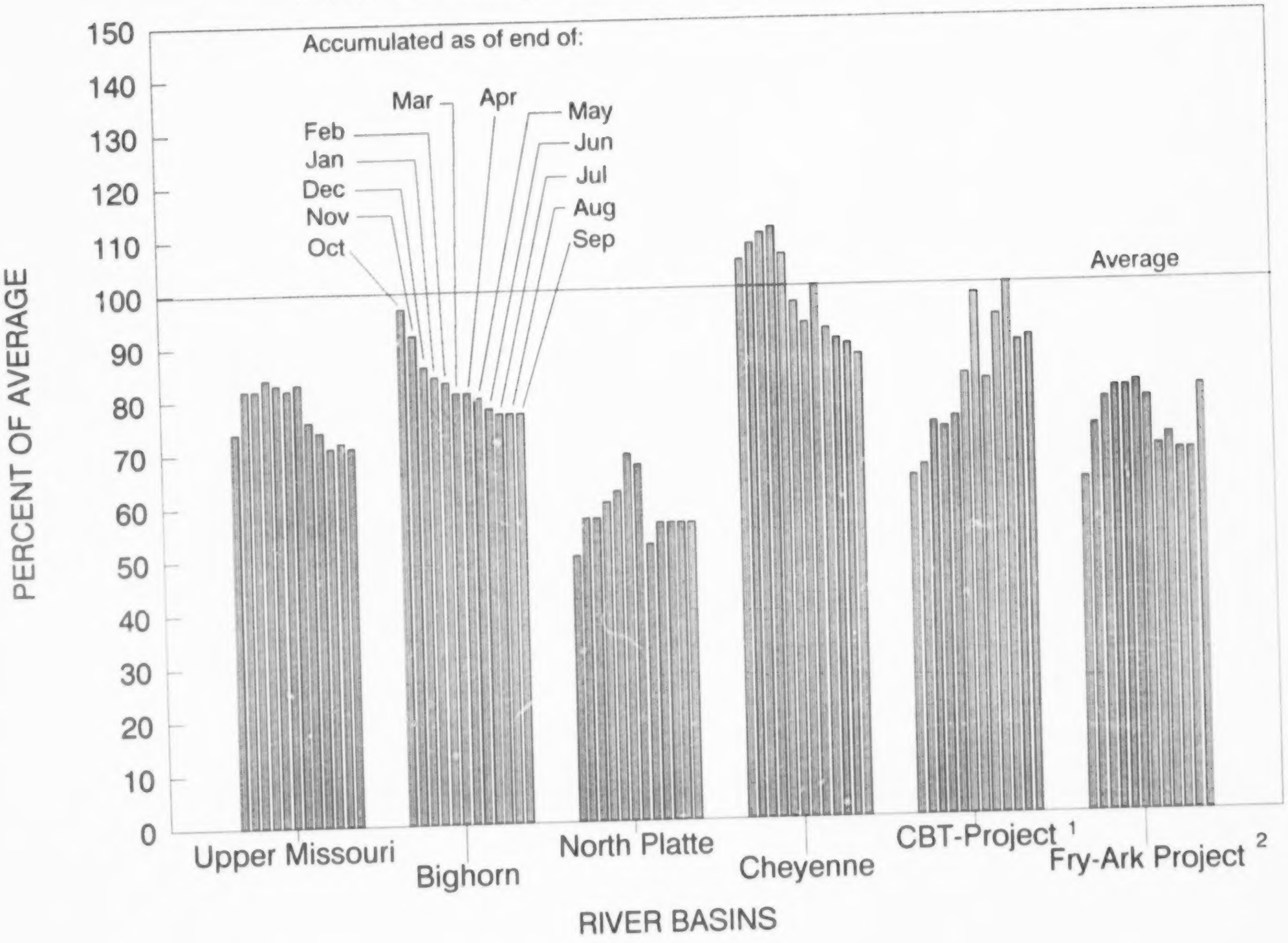
(Review Of What The Forecasts Were)



Notes: 1. Colorado Big Thompson 2. Data Source: "Water Supply Outlook For The Western U.S." By The Soil Conservation Service and National Weather Service

Water Year 1990 Accumulated Inflows, Great Plains Region

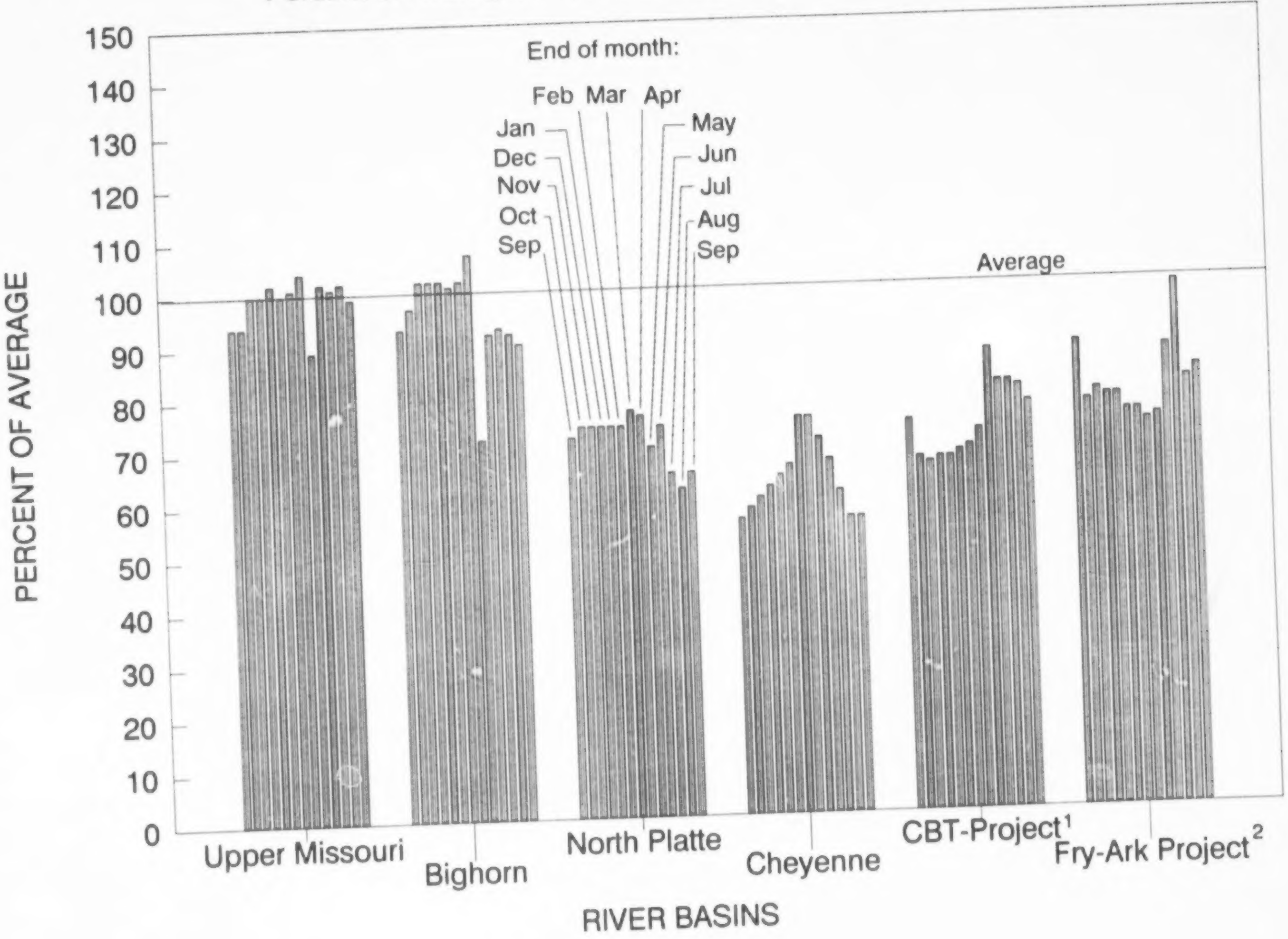
Percent of Average, October 1, 1989 to September 30, 1990



Notes: 1. Colorado Big-Thompson 2. Fryingpan-Arkansas

Water Year 1990 Reservoir Storage, Great Plains Region

Percent of Average, September 30, 1989 to September 30, 1990



Notes: 1. Colorado Big-Thompson 2. Fryingpan-Arkansas